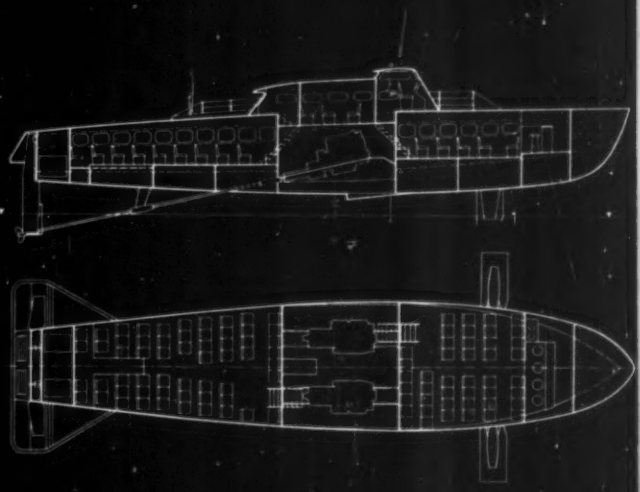
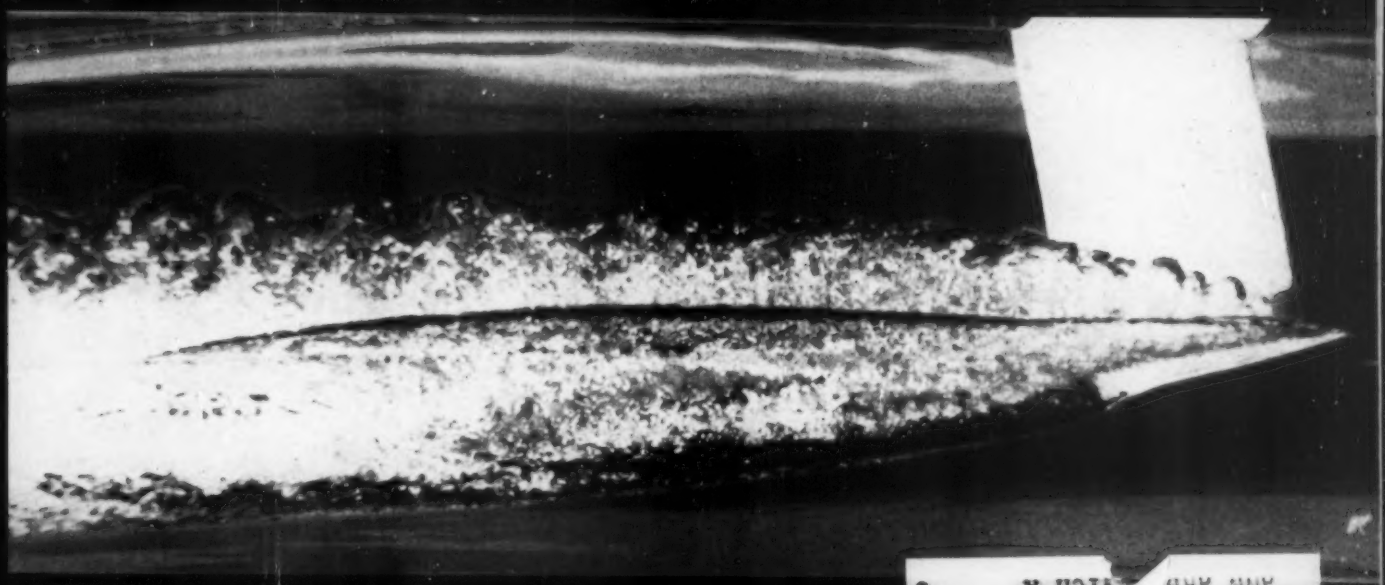


underwater flight...HYDROFOILS... *see page 3*



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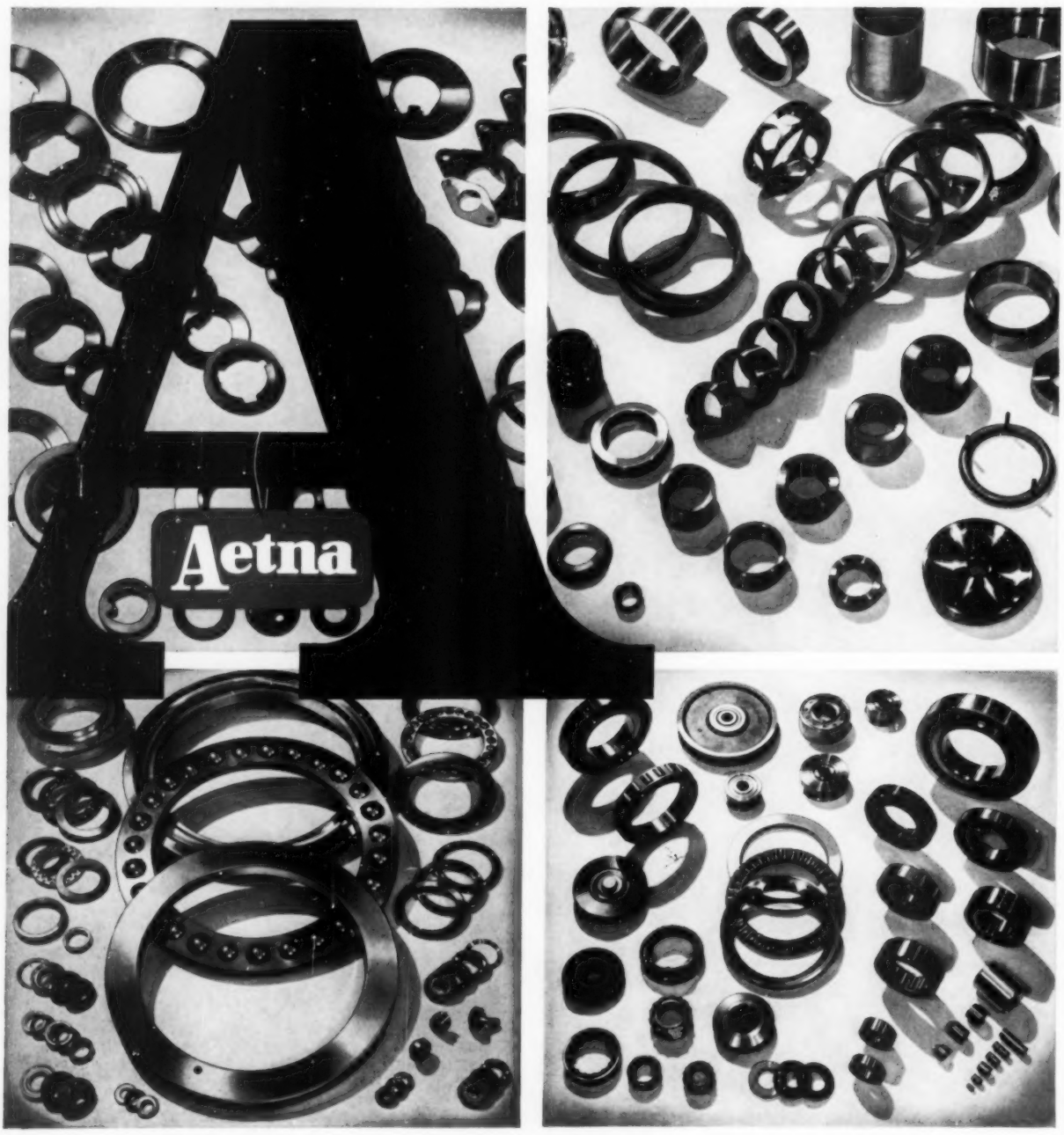

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

July 17, 1961 Vol. 32, No. 29

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How to choose a metal for sub-zero service

What metal do you use in equipment for sub-zero studies in chemistry and physics... in pressure vessels and auxiliary equipment for storage of ethylene at −155°F... in tanks and ocean-going barges that must handle liquefied gases at −258°F... in storing and piping equipment for liquid nitrogen at −320°F or liquid helium at −452°F?

Just any metal won't do: in each case the equipment must be made of a metal that retains its toughness where other metals embrittle in crippling sub-zero temperatures.

Which metal to use... and where?

2¼% NICKEL STEEL

For moderately low temperature service, this nickel steel offers a combination of good mechanical properties and superior resistance to brittle fracture at temperatures down to −75°F. 2¼% nickel steel may be found at work in refrigeration equipment, cooling apparatus, and machinery and structures in very cold climates.

Design Data

ASTM A-203 Grade	Tensile Strength psi, min.	Yield Strength psi, min.	Allowable Tensile Design Stress ASME, psi, max.
A	65,000	37,000	16,250
B	70,000	40,000	17,500

Welding Materials: For manual metal-arc welding, use low hydrogen coated electrodes of the E8015-16-18 C1 Classification conforming to AWS-ASTM specification A316. These electrodes will deposit a weld metal of essentially base metal composition.

3½% NICKEL STEEL

Low carbon 3½% nickel steel has both high strength and a resistance to brittle fracture which has led to its use as a standard material for pressure vessels operating at temperatures down to −150°F − vessels for manufacturing, storing and transporting liquefied hydrocarbons. It is also widely used in aircraft testing units and equipment for oil refinery processes.

Design Data

ASTM A-203 Grade	Tensile Strength psi, min.	Yield Strength psi, min.	Allowable Tensile Design Stress ASME, psi, max.
D	65,000	37,000	16,250
E	70,000	40,000	17,500

Welding Materials: For manual metal-arc welding, low hydrogen type electrodes of AWS-ASTM Classification E8015-16-18 C2 will deposit weld metal containing not over 0.10 carbon and 3% to 3½% nickel.

9% NICKEL STEEL

Low carbon 9% nickel steel provides an excellent combination of strength and notch toughness at temperatures down to −320°F. Specifically developed to meet engineering demands for an economically priced metal for low temperature service, this material is produced in the quenched and tempered or double normalized and tempered conditions. Operation Cryogenics has demonstrated that this material may be used safely even without thermal treatment after welding. At the present time an ASME code case is being prepared to use pressure vessels made of either of these conditions, omitting the post-weld heat treatment. 9% nickel steel is at work in equipment handling such products as liquid methane at −258°F, oxygen at −297°F, and nitrogen at −320°F.

Design Data

ASTM A-353 Grade	Tensile Strength psi, min.	Yield Strength psi, min.	Allowable Tensile Design Stress ASME, psi, max.
A	90,000	60,000	22,500
B	95,000	65,000	23,750

Welding Materials: Best results are obtained with Inco-Weld* coated electrodes or wire of a high nickel-chromium-iron composition. Inco-Weld "A" electrode is used for manual welding, and Inco-Weld "A" wire is used for inert gas welding with tungsten electrode or inert gas-metal arc welding.

304 NICKEL STAINLESS STEEL

Types 304 and 304L nickel stainless steels are very well-suited for service at extreme sub-zero temperatures down to −452°F, the temperature of liquid helium and the lowest measured service temperature. These nickel stainless steels are widely used in low temperature service because they are easy to fabricate, do not require heat treatment after fabrication, and have high strength with superior ductility and shock resistance at very low temperatures. And because of their corrosion resistance, nickel stainless steels are employed wherever high product purity and ease of cleaning following fabrication are essential − as in the handling of missile propellants. In fact, for optimum *corrosion resistance* at *any* temperature in the sub-zero range, nickel stainless steels are the best choice.

Design Data

ASTM A-240 Grade	Tensile Strength psi, min.	Yield Strength psi, min.	Allowable Tensile Design Stress ASME, psi, max.
304	75,000	30,000	18,750
304L	70,000	25,000	17,500

Welding Materials: For metal-arc welding, use coated austenitic stainless steel electrodes conforming to AWS Classification E308 ELC-ASTM A298. Inert gas-metal arc welding requires ER308L wire conforming to ASTM A371.

Cold Facts on Metal Economy

Interestingly enough, the nickel alloy steels increase significantly in strength as the temperature is lowered into the sub-zero range. For example, 9% nickel steel has a tensile strength at room temperature of 105,000 psi; at −320°F its tensile strength is 165,000 psi.

The high room temperature tensile properties of these nickel alloy steels which manifest themselves in higher code design strengths makes it possible to use thinner, more economical sections with complete safety. As the structure is cooled to its sub-zero operating temperature, the characteristic response of the nickel steels − an increase in strength while still maintaining toughness − further confirms the wise selection of these steels in sound engineering design.

LITERATURE

The publications listed below are especially recommended for guidance in selecting metals for sub-zero service.

Publication Number	Name
A269	Properties of Nickel Steel Plates at Low Temperatures
A263	9% Nickel Steel for Low Temperature Service
A278	3½% Nickel Steel for Low Temperature Service
A273	2¼% Nickel Steel for Low Temperature Service
	Operation Cryogenics
A276	Steels for the Containment of Liquefied Gas Cargoes

A complete listing of Inco publications and technical bulletins can be obtained by writing for "List A" to:

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INTERESTING TO NOTE

On our cover—the waterfoil is being towed in one of the test basins at the Navy's David Taylor Model Basin, Carderock, Md. At top left is the hydrofoil designed and manufactured for the Maritime Administration by Grumman Aircraft Engineering Corp and its subsidiary, Dynamic Development, Inc. See story, p. 15.

The magnificent pump at Marley

Ingenious pumping devices go back to early near-Eastern civilizations and through the centuries have displayed a remarkable amount of mechanical sophistication. (One new pumping device is powered by a hand drill—see page 32.) Perhaps the most elaborate early pumping system was built in France during the reign of Louis XIV to carry water to his Versailles fountains from the Seine 4 miles away.

With 14 water wheels of near-40-ft dia and chain drives as long as 2130 ft, the machine was considered one of the wonders of the world. In fact, the machine became so renowned that a legend sprang up about the royal treatment accorded by Louis XIV to its designer, an illiterate carpenter from Liege named Rennequin Sualem. As the story goes, the king was so proud of the machine that he had Sualem's eyes put out. The royal reasoning: blind, Sualem couldn't build a bigger installation for some other monarch. Actually, Sualem received so much gold for his services, he never had to work again.

The project began when the king had town criers throughout his realm pass the word that anyone who had ideas on pumping water from the Seine to Versailles should come forth. An insider at the court, one Arnold de Ville, heard about the competition and remembered an impressive pumping installation near his home town of Liege. He located the designer of the installation, the carpenter Sualem, and had him make a reduced scale working model for a proposed Seine pumping station. Louis XIV was impressed and gave Sualem the go-ahead. Construction started in 1681. Seven years, 1.7 million pounds of copper, 34 million pounds of iron and 170 million pounds of wood later the machine was ready.

Limitations of materials available to its designer had, as today, considerable effect on the concept of the machine. The 14 water wheels drove 64 piston pumps delivering Seine water to a reservoir 168 ft up the hill. At this reservoir, a second group of 79 pumps raised the water another 185 ft to a second reservoir, where a third group of 78 pumps lifted the water an additional 196 ft to the aqueduct that carried the water to Versailles. Sualem had to use so many pumps because only small cast-iron pipes could be manufactured and they couldn't handle high pressures. The joints were the limiting factor

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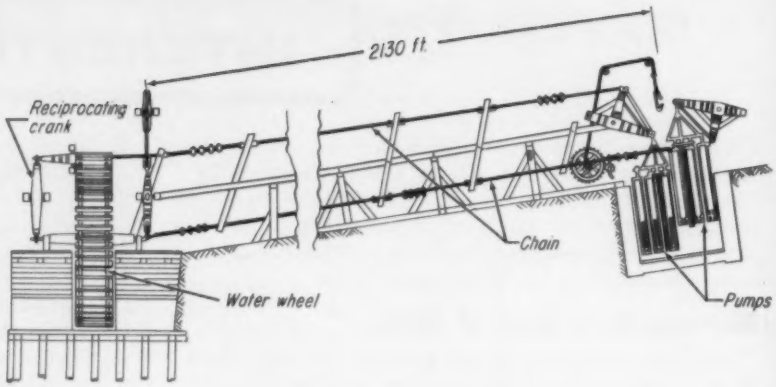
—flange faces were used as cast and wedge-shaped pieces of wood served as the gasketing material.

Although Sualem was unschooled to the extent that he couldn't sign his name, he did have some inherent feeling for reliability. All the pumps were the same size—6½ in. dia with 4-ft stroke—but Sualem put more pumping capacity at the two upper reservoirs than he did at Seine level, where the pumping started. He apparently realized that the long chain drives powered by cranks on the water wheels would break down (as they often did) and therefore designed the equipment at the two reservoirs with enough capacity to handle, despite breakdowns, all the water pumped up from the river. The chain drives, called *chevalets*, were made up of links either 1½ or 3 in. thick. One, *Le Petit Chevalet* was 656 ft in length, ran from the water wheels up to the first reservoir where it drove 49 of the pumps. The *Grand Chevalet* was 2130 ft long and powered 30 pumps at the first reservoir and all 78 at the second reservoir.



But for other parts of the machine, Sualem's design intuition wasn't enough. The bearings, for example, all had copper linings to prevent iron-to-iron contact but they were badly fitted and often overheated and started fires. A water-cooling system had to be installed to keep temperatures down. This reduced the number of fires but didn't stop the bearings from wearing out. The machine had 412 copper bearings weighing from 12 to 200 lbs each and several of each size had to be stocked to keep the machine going. Another weak point in the design turned up in the 28 wooden cranks, two for each water wheel. Although reinforced with iron, they broke so often that a spare for each had to be available.

Certainly one of the major causes of the continued breakdowns of the machine was bad distribution of loads on the water wheels and the crank arms. The first wheel developed 29,807 lbs of force and used only 18,074 lbs. The second and third wheels were also overpowered but the fourth wheel lacked by 6488 lbs the force necessary to drive the pumps connected to it. It was rare when more than nine of the 14 wheels were in operating condition at the same time.

Despite the problems, Sualem's machine did run, and when it was new pumped as much as 1,300,000 gallons of water a day to Versailles. As the years and the machine wore on, capacity dropped off considerably. By 1780, it was averaging less than 264,000 gallons a day, and in 1817 it was stopped. A temporary machine and then a steam machine filled the gap until Napoeon III's hydraulic machine, which is still operating today, went on the line in 1856.

—Benedict A Leerburger Jr

NEXT WEEK IN PRODUCT ENGINEERING

. . . Mechanical counters for speed—and economy

What kinds are available for 1000 to 3000 rpm? What are their strengths and weaknesses?

. . . Friction and wear for water-lubricated seals

Tests show that graphite against chrome-plated steel gives best combination of low wear rate and low friction.

. . . New techniques for photoelastic stress analysis

Where to put metal and where to take it away? Here are six techniques to eliminate the guesswork on "impossible" jobs.

. . . Magnetically suspended bearings

Already in gyros, they show possibilities of competing with air bearings for iightly loaded instruments.

. . . Panel-stops leave hands free

They hold panel doors open while repairs or adjustments are made.

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WHAT'S HAPPENING IN RESEARCH...

Little bulbs stand big pressures

Miniature lamps—penlight, instrument, and small neon bulbs—can take pressures as high as 10,000 psi without mechanical or electrical failure, Naval Research Lab reports. NRL has been testing a wide range of electrical and electronic components at high hydrostatic pressures as part of a development progress for underwater equipment, now says that, while some miniature tubes failed by catastrophe implosion or by oil leaks through the seal at pressures as low as 2000 psi, "a high percentage were found capable of withstanding the full 10,000 psi load." The results indicate, C. L. Buchanan and M. Flato say, that "where need arises, components in glass envelopes may be used in high-pressure environments."

Note: For reports on other high-pressure studies at NRL, see *(PE—Mar 6, p 6; and for more on miniature lamps, see July 18 '60, p 57.)*

Putting brittle materials to work

Because the materials that offer the greatest heat resistance—refractory metals, ceramics and plastics—also tend to be brittle, a good many studies are now in progress to find out what makes a material brittle and how to compensate for it in structural design.

The effects of heat treatment, surface condition, rate of strain, and thermal cycling must also be investigated.

One recent survey, by G. T. Hahn and R. I. Jaffee of Battelle Memorial Institute, rounds up a good deal of data on elastic and plastic deformation, tensile strength, yield strength, and elongation, ductile-to-brittle transition points, reduction in area, and strain at fracture for more than a dozen metals and ceramics. This survey will be available (as PB 171,626) from OTS, Dept of Commerce, Washington 25, D.C. in about two months.

As Hahn and Jaffee point out, brittle materials can successfully be used by restricting service to temperatures above the transition from brittle to ductile and maintaining stresses below the level required for crack propagation. But, though brittle materials like cement and cast iron have been used in structural applications for years, much new data on fracture-toughness and notch-sensitivity is needed to guide use of the newer materials.

Also soon to be available from the same source (as PB 155,267) is an interim report on a long-term Naval Research Lab study of crack propagation in high-strength, semi-brittle materials. It's NRL Report 5617 by J. R. Srawley. (For earlier studies at Battelle and NRL, see *PE—Aug 24 '59, p 14 and Jan 4 '60, p 8).*

Briefing the Soviet record

Electrical resistivity of nickel-chromium-tungsten alloys varies with heat treatment as well as alloy percentage, USSR researchers report.

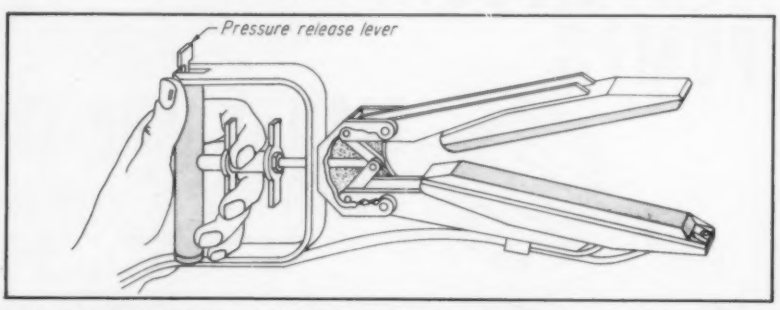
Tests at Baikov Institute of Metallurgy indicate that the 5% tungsten alloy in the annealed condition shows a maximum specific electrical resistance at 30% chromium; but the quenched alloy has a maximum at 35% chromium. The reason: the specific electrical resistance is highest when the solid solution is saturated with respect to chromium, and the solubility varies with temperature. A wide range of alloys, with chromium and tungsten contents ranging from 2 to 30%, was tested and a detailed report appeared in *Zhur. Neorg. Khim*, Vol 5, 1960.

A high-sensitivity bolometer, cooled by liquid nitrogen, is reported by two Soviet research scientists. In this radiant-heat sensor, nickel strips form two arms of a Wheatstone bridge; and, by cooling the nickel to liquid nitrogen temperatures, the Soviets say, it is possible to increase the threshold sentitivity 20-fold. The device still is not as sentitive as systems operating in the liquid helium range. But, they say, it is more compact and less expensive, and is proving useful in connection with infrared spectroscopic devices. A report on it appeared in the USSR publication *Optics and Spectroscopy*, v.9 No 4, p 530.

(Note: for more on radiant-heat detectors, see *PE—Feb 20, p 6)*—**ARG**

Low-cost welder for plastic film

A single length of Nichrome ribbon (5 by ⅜ by 0.001 in.) and a pair of clamps are giving Lawrence Radiation Lab scientists a simple, inexpensive way to weld plastic film. Their primary use: to seal radiation-contaminated equipment in plastic bags. The device can be used almost anywhere, though. As LRL engineers proudly point out, it's portable, warms up almost instantly, and will handle films at least to 10 mils thick. It operates on a standard 10-v filament transformer rated at 5 amp, with a powerstat in the circuit to adjust heater current. An automatic timer, push-button and pilot light are provided. Sealing time is 5 to 8 sec.



PLASTIC WELDER has pistol grip with links that are drawn back as fingers are closed to force jaws together. One jaw is pin-mounted; the other has adjusting screw to control clamp pressure. Thumb lever unlocks jaws.

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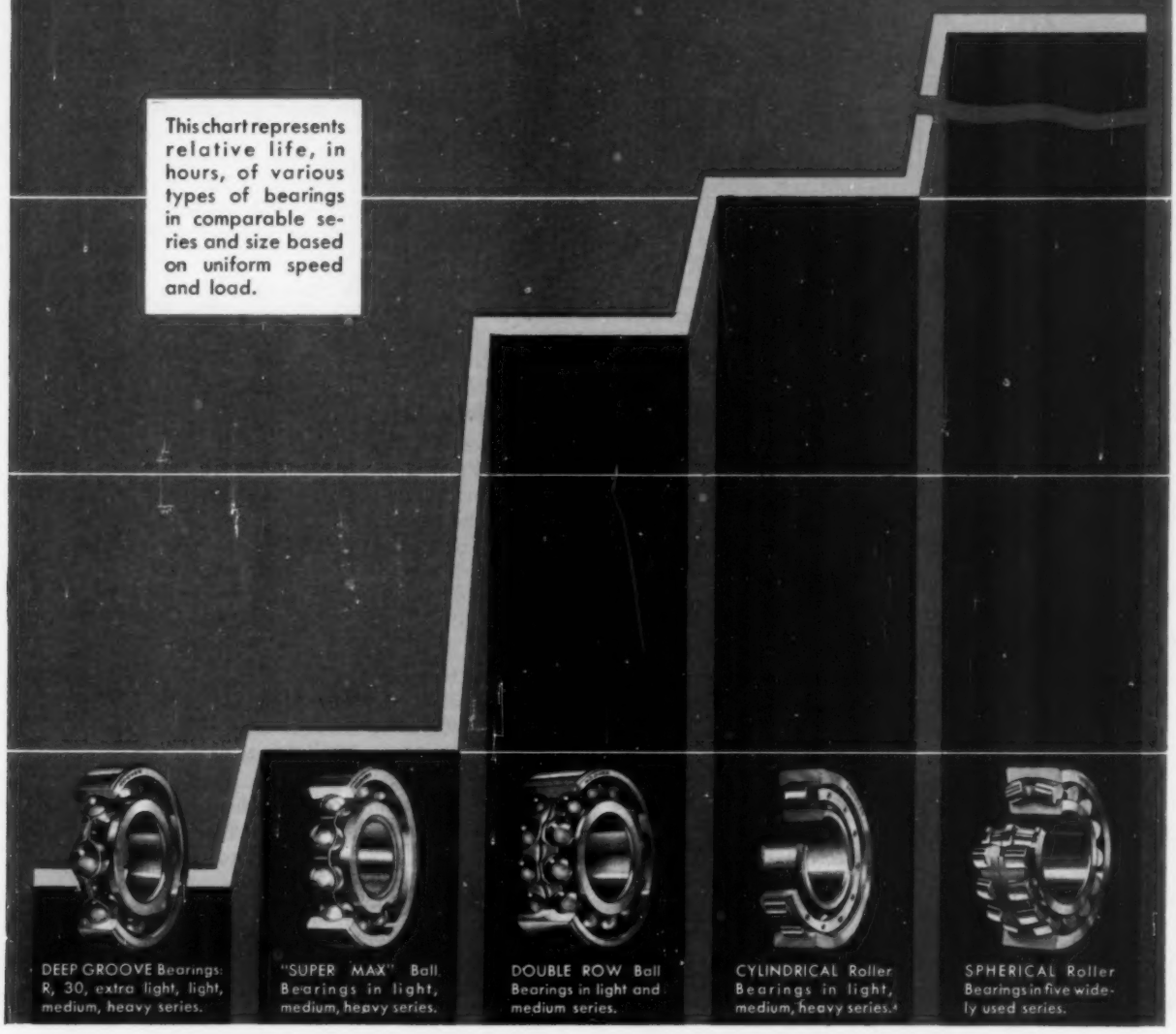
This chart represents relative life, in hours, of various types of bearings in comparable series and size based on uniform speed and load.
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DEVELOPMENTS TO WATCH...

Fused quartz tape for high-temp insulation

For thermal and electrical applications requiring higher heat resistance than can be provided by conventional glass fiber products, Amersil Quartz, Hillside, NJ, has fused quartz tape ready for evaluation in sizes from 2 to 8 in. wide (fiber dia: 5 to 7 and 8 to 10 microns).

As Amersil points out, fused quartz has excellent electrical properties (dielectric strength 410 volts/mil; dielectric constant, 4.4). Its fusion point is well above 3000 F, and it will stand continuous operating temperatures at least to 1800 F. Like conventional glass fiber, though, the fused quartz tape is relatively limited in abrasion and wear resistance, will probably require some sort of protection from chafing.

As might be expected, the material is far from inexpensive. In evaluation quantities, the 4 in. tape (8-to-10 micron dia) is $5:30/ft ($9.35/ft. in 5-to-7 micron fibers) and the 8 in., 8-to-10 micron tape is $10.60/ft; the 5-to-7 micron, $18.70/ft.

Low-cost copper alloy challenges high-nickel materials

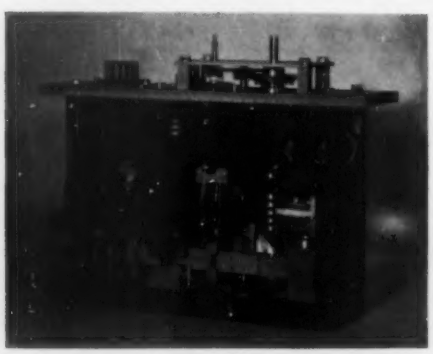
A copper-nickel alloy with properties "practically identical to those of nickel alloys" but approximately half their price, is under development for heat exchanger tubing and other applications. Phelps Dodge Copper Products says experimental condenser tubing made with the new alloy has a tensile strength exceeding 85,000 psi and can stand temperatures well over 600 F. Nominal composition is 56% Cu, 41% Ni, 2% Fe, 1% Mn.

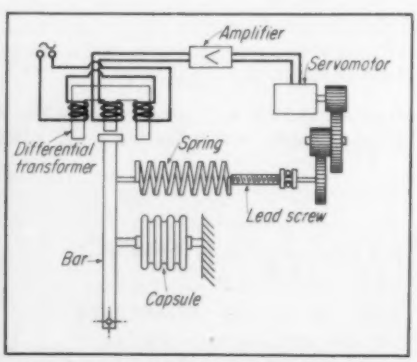
New pressure transducer designed in Britain

A pressure transducer which can be used for both differential and absolute measurement, is being introduced by Kelvin & Hughes Ltd. Barkingside, Essex, England. The company says it's more accurate than previous designs because it measures force output rather than deflection; and it can be produced in pressure ranges to 200 psi, with an overall accuracy, at room temperature, of 0.1% of total pressure range.

In the system (see diagram), pressure on the capsule causes movement of a bar which is detected by a differential transformer and amplified by a transistorized unit which feeds the control phase of a servomotor. As the motor shaft rotates, it drives a lead screw, exerting pressure on a spring, which is attached to the bar, until it restores deflection of bar and capsule to zero. Thus, angular rotation of the screw becomes a measure of capsule force and therefore of the applied pressure. (In practice, two capsules are used, one on each side of the pivot—see photo. For absolute pressure measurements, one of these is evacuated.) The output is via a shaft from the gear box, and the unit can be arranged for synchro transmission or to operate a slide-wire potentiometer.

The first model is a 115 v—400 cycle—3-phase unit, but a 60-cycle model is now being designed.

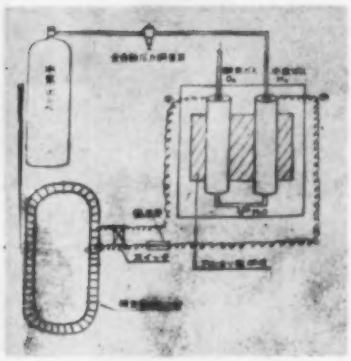




IN FORCE-BALANCE TRANSDUCER, change of pressure in capsule results in movement of the bar which is supported on cross-spring pivots. Bar is statically balanced, and bimetal compensator is provided to minimize temperature errors.

Japanese fuel cell goes into commercial production

Openly challenging American manufacturers, Matsushita Electric Industrial Company of Osaka is planning to produce a low-temperature, low-pressure hydrogen-oxygen fuel cell of the carbon electrode type. The prototype model, shown here running a toy train, consists of 10 cells (1 volt, 3 amp) and weighs 11 lb. Thermal efficiency, says Matsushita, is 70%. Hydrogen gas is the fuel, air is the oxidant, and caustic soda is the electrolyte. The carbon electrodes are "hollow, waterproof cylinders."



JAPANESE FUEL CELL runs a model train. Diagram (Matsushita's own) shows how the fuel cell and track are set up.

Subminiature capacitors head for 400 F

A new dielectric material for low-voltage (0.01 mf and up) subminiature capacitors is being readied for introduction by Radiation Research Corp, Westbury, LI. It's said to stand temperatures to 200 C, and to permit design of capacitors less than half the size of other film capacitors for the same range.

Key to the new material is a new process, first applied to Mylar film, and now being extended to Teflon. The process starts with Teflon tape, metallized on both sides. This is then exposed to TFE fluorocarbon resin in monomer (vapor) form. As the resin is deposited, it is polymerized in place by glow-discharge to produce a coating that is said to be unusually uniform and free from pinholes.

Experimental 50- and 100-v capacitors are now being made with the material and will shortly be available for evaluation.

Plastic drive belts shine in satellite tests

Driving belts of oriented polyester (Mylar) film rate consideration for many mechanical instrumentation and power transmission applications, say J. H. Licht and Arthur White of Goddard Space Flight Center, after examining polyester drives used in tape recorders and other satellite instruments. The polyester belts, they say, show good fatigue resistance and high stress tolerance.

With such belts, pitch-line variations can be held to as little as 0.001 in.—about a tenth of that found even in high-quality fabric belts.

Belts in the ½-mil thickness can be applied to shafts as small as 0.040 in. "with reasonable life," permitting development of ultraminiature drives that might accomplish reductions as great as 1000 to 1 in a mechanism with a volume of only ½ cu in.

Heavier belts (about 5 mils thick) show promise for machine-tool drives. In one test, such a belt was substituted for a fabric-and-rubber belt on a 1/12-hp, 22,500 rpm tool-post grinder.

Licht and White also note these points for design attention:

- Coefficient of thermal expansion at normal operating temperatures is very near that of magnesium and aluminum alloys.
- Heat treatment will significantly increase its torque capacity.
- The surface charge that accumulates can be used to retain belts in position and keep them from rubbing when belts are declutched by idler pulleys.

High-columbium titanium alloys headed for high-temp jobs

Addition of columbium, in weight percentages on the order of 30%, markedly increases the tensile strength of titanium, and the alloys show definite promise for high-temperature structural use, Naval Research Lab reports. It's been testing a whole series of binary alloys, ranging from 90% Cb to 90% Ti, found the hardest alloys to be close to the two ends of the scale. The best showing was made by levitation melted alloys containing about 80% Cb and vacuum arc melted alloys with about 70% Ti. They showed ultimate tensile strengths in the 110,000 to 130,000 psi range. —ARG

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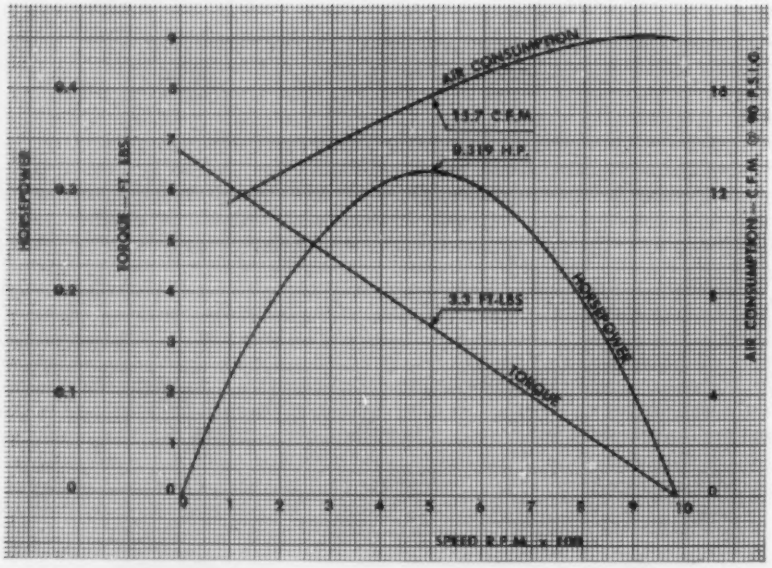

Sample motor performance chart

TECHNICAL DATA:

Motor Performance Charts, Dimensional Prints, and other specification data are available to help you with design problems.

For complete information, call or write

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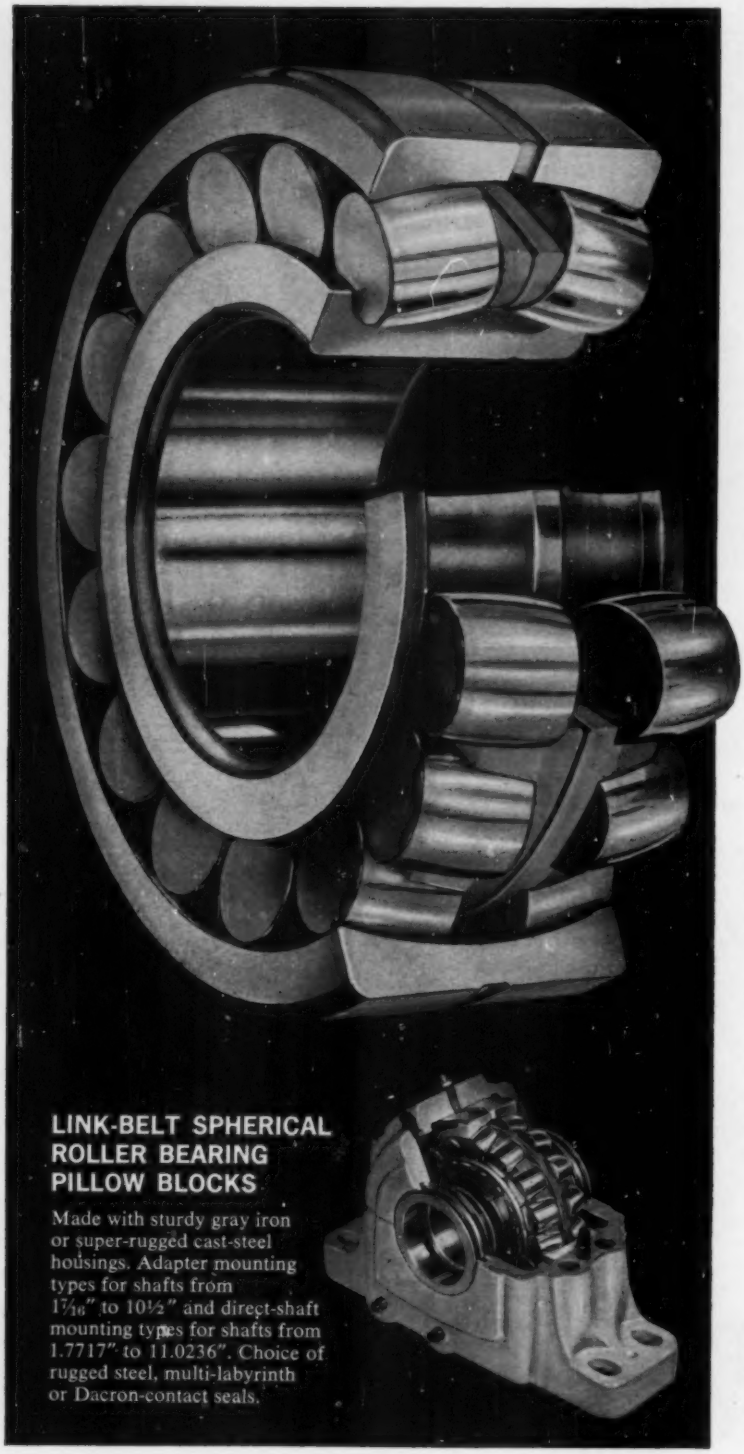
LINK-BELT SPHERICAL ROLLER BEARINGS:

measure these design values in terms of your applications



LINK-BELT SPHERICAL ROLLER BEARING PILLOW BLOCKS

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GREATER CAPACITY!

The reason? *More rollers, larger rollers!* Bearing capacity depends primarily on effective roller Length, roller Diameter and Number of rollers (L x D x N). And Link-Belt offers the *largest effective roller complement* for all sizes of spherical roller bearings . . . rated according to accepted formulas of the Anti-Friction Bearing Manufacturers Association. This increase in LDN values provides extremely high capacity . . . and in users' evaluation, it adds up to far longer bearing life.

GREATER DURABILITY!

With balanced proportion design, Link-Belt spherical roller bearings possess durability characteristics that exceed the bearing industry's exacting requirements. Optimum balance of rollers, inner and outer rings must be obtained for increased bearing capacity . . . yet overall bearing dimensions must conform to an established international standard boundary plan.

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Link-Belt spherical roller bearings are made in the world's most modern bearing plant . . . with the most-advanced tools and techniques known to industry. A rigid quality control program leaves *nothing* to chance. Each Link-Belt bearing is subjected to *758 actual inspections*. Microsmoothness and precision are continuously scrutinized by automatic machines. Result: these bearings have been specified by leading manufacturers of cranes, shovels, graders, vibrating screens, and steel mill, paper mill and foundry equipment . . . and for high-precision applications such as embossing rolls, printing presses and torque converters.

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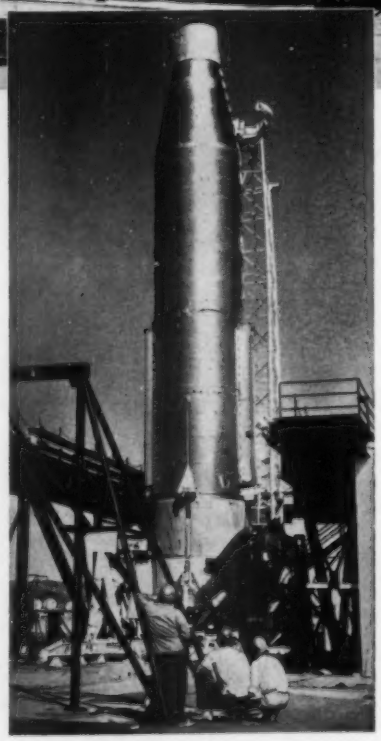
CONVAIR ERECTOR-LAUNCHERS RELY ON POWERFUL PHILADELPHIA GEAR DRIVES

Atlas ICBM in stored position. Arrow points to heavy duty Philadelphia Gear hoist drive, which quickly erects missile to launch position for skyward voyage. Erector-launcher designed and built by Convair (Astronautics) Division of General Dynamics Corporation.



Atlas can now lie low till needed . . .
new hoisting mechanism eliminates massive gantry towers

The Air Force has equipped itself with a new missile hoist mechanism which is both speedy and powerful. These two requirements plus ultra-reliability have qualified Philadelphia Gear Drives for the moments-notice job of erecting Atlas to launch position. The "Big Punch" is now stored horizontally. These erector-launchers are now operational at Atlas ICBM complexes at Warren Air Force Base, Wyoming.

The Philadelphia Gear Drive is a standard, all-steel, parallel shaft reducer. Output torque is 634,000 lb/inches at 7½ rpm, on low speed shaft; 1,250,000 lb/inches under emergency conditions; ratio—234:1. All units are load tested to 300% of normal rating.

Standard Philadelphia heavy-duty drives are right at home in any application that demands an extra margin of reliability. Our engineering specialists in all kinds of power transmission problems have made sure Philadelphia Gear equipment has more than kept the pace to help America keep the peace. To see what can be done in gearing today, write for our catalog "Philadelphia Parallel Shaft Speed Reducers," No. H-58.

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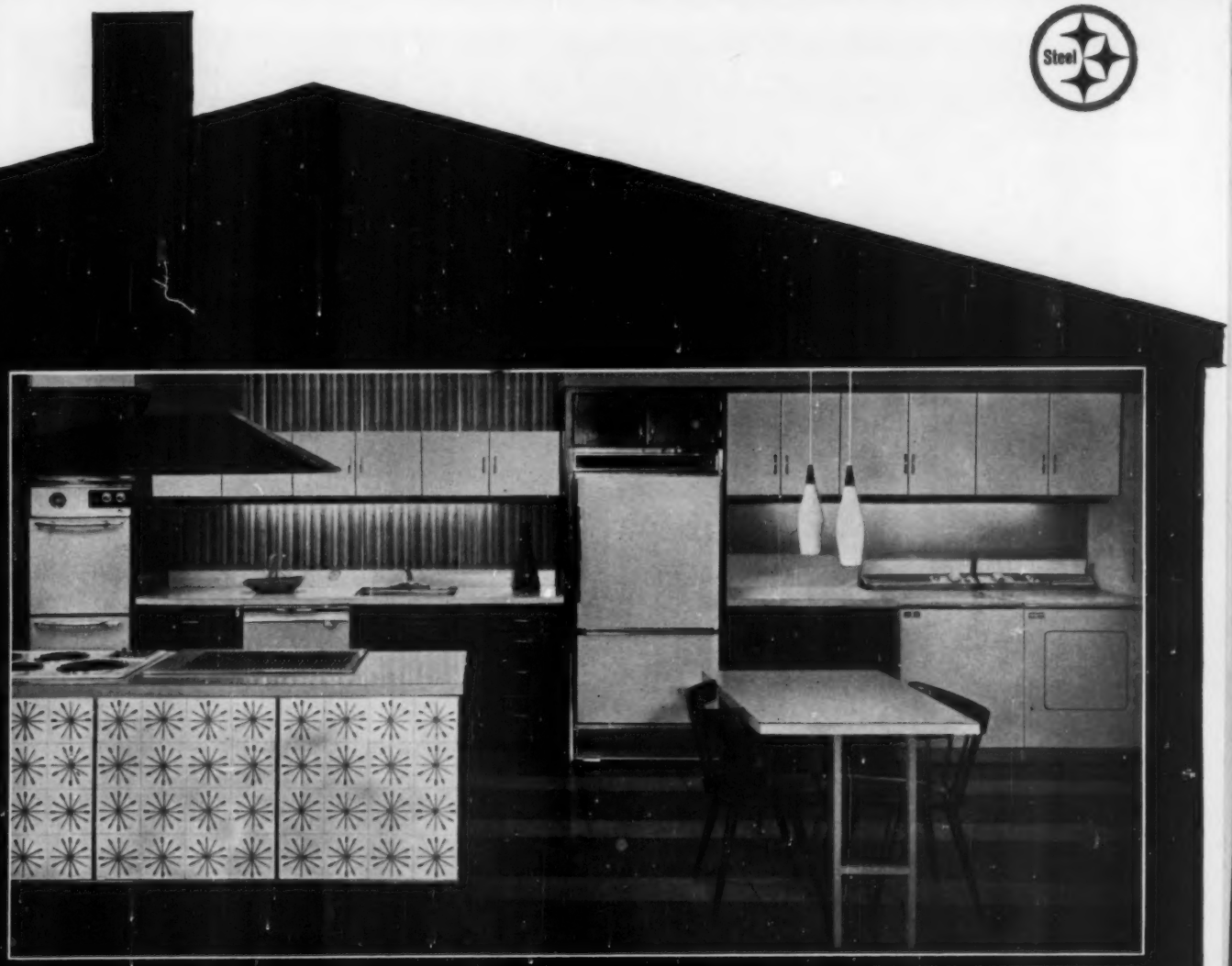

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OR TAKE WEIRZIN®—an electrolytically zinc-coated steel with excellent corrosion resistance and, when chemically treated, superb paintability. These advantages, plus Weirzin's economical, flawless fabrication, make it an ideal choice for strong, durable, good looking kitchen cabinets.

OR WEIRTON COLD-ROLLED STEEL—to give you a fine, smooth finish and unexcelled ability to withstand the severe forming operations necessary for intricate designs.

OR PRE-PAINTED OR VINYL-COATED WEIRTON STEELS—Factory pre-painting of Weirkote and Weirzin or cold-rolled steel offers you built-in economy, controlled quality and any shade you might want. Vinyl coating, done by National Steel's Enamelstrip Division of Allentown, Pennsylvania, can be ordered in almost any texture and color. Any Weirton Steel goes through all production steps flawlessly and economically.

TAKE MODERN STEEL—particularly in any of the forms mentioned above. For full details, write Weirton Steel Company, Weirton, West Virginia.

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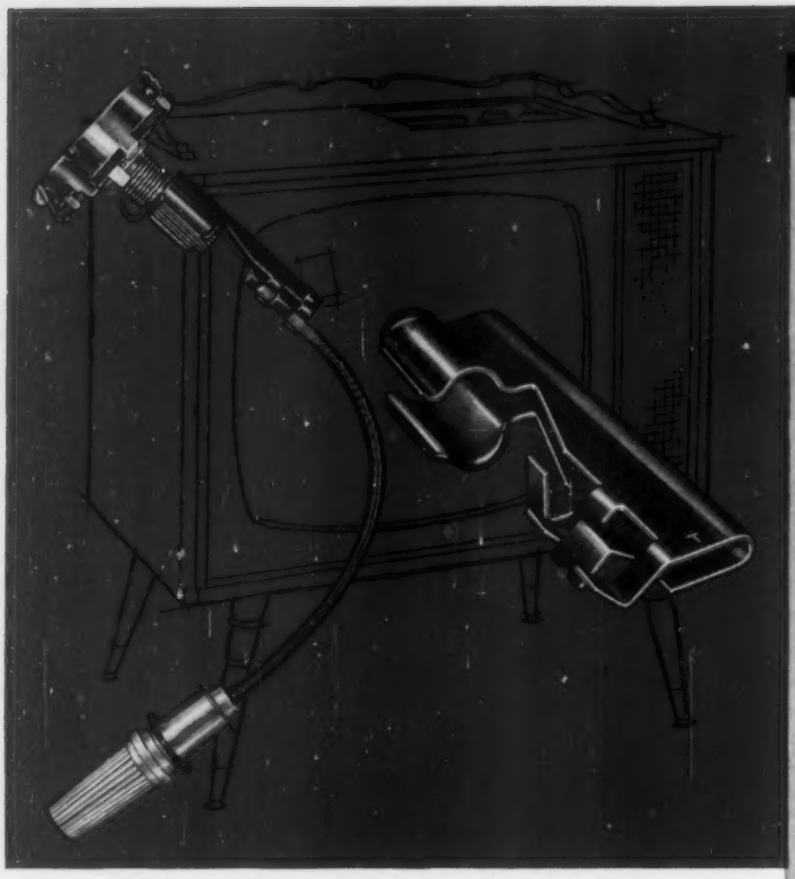

A Tinnerman T-Marked Original...

SPEED CLIP® gives Sylvania easier, more reliable, more flexible assembly

This new Tinnerman-engineered SPEED CLIP fastener provides a faster, more flexible connection between control "pots" and knobs on a TV manufactured by Sylvania Electric Products, Inc. The fastener can be applied wherever similar components are mounted and space limitations pose an assembly problem.

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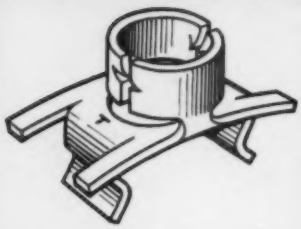
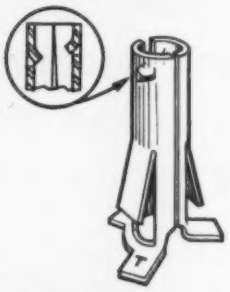


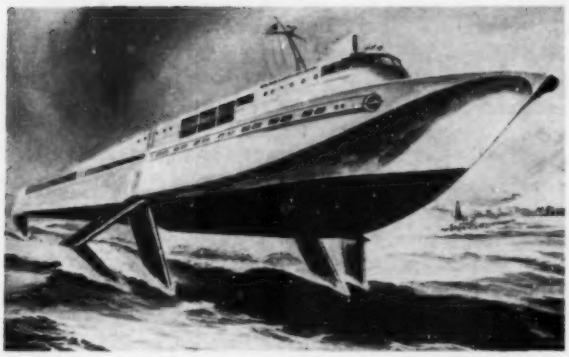
TRANSISTOR CLIP saves weight and space, snaps quickly into panel . . . no screws, rivets. Designed for coil form retention, this SPEED CLIP fastener proved ideal for fastening transistors. Tubular retaining collar has excellent heat sink properties, openings at sides and bottom allow air circulation.

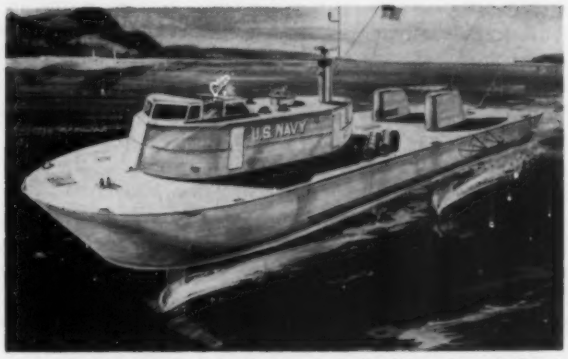
FRONT MOUNTING SPEED CLIP FASTENER cuts front panel assembly costs on popular washer-dryer. Unique self-retaining SPEED CLIP fastener permits simplified front mounting for easier, faster, lower cost assembly of front panel. No welding, staking, screw driving . . . ends scrap hazard. Four fasteners engage panel mounting flange as it slips in place over curved spring fingers. Assures firm vibration resistant assembly, yet easy removal for servicing.



BOWDEN CABLE CLIP is one of many Tinnerman designs to fasten armored cable. Designed for car instrument panels, it's the perfect answer to through-panel cable fastening problems. No welding, staking, clinching, no special mounting brackets or clamps. Live spring tension prohibits vibration . . . prevents loosening.

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S.A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano Simmonds GMBH, Heidelberg.





SURFACE-PIERCING FOILS of the Maritime Administration's H M Dennison, under construction at Grumman, contrast sharply with the completely submerged foils of the Navy's patrol craft being made at Boeing. The Dennison will be 104-ft long, 21 ft in the beam and will cruise at about 60 knots. The patrol craft will be 115 ft long; 31 ft in the beam and will cruise at 40 to 45 knots. Both are forerunners of higher-speed and larger crafts.

Hydrofoils: a promise of high-speed water travel

50 years of small-company and individual research developed the basic concepts of hydrofoil design. 10 years of government sponsored research and engineering proved the concepts and improved on early foil designs. Now, the Navy and Maritime Administration are constructing hydrofoil craft and foresee large, high-speed stable ships in the near future.

NEW YORK—The next few years will see an explosion in hydrofoil technology—if the promise of current research and construction is realized. Work on hydrofoils is now intense and wide spread: the Navy is supporting a multimillion dollar research program to break the barrier into supercavitating speeds; the Maritime Administration will soon begin evaluation studies on a 90-ton-displacement craft that may spawn a fleet of passenger ferries; and European and Asiatic designers are making steady improvements (and an enthusiastic sales pitch) for their hydrofoil concepts presently proving themselves on passenger-carrying vessels.

As designers see it, within 2 years technology should be available to build a 500-ton-displacement craft, capable of traveling at 100 knots on open seas. This is well beyond the speed at which water begins to cavitate around foils. It raises manifold problems of propulsion, control and hydrofoil configuration.

The Navy's assault on hydrofoils began in earnest about a year ago. At that time, the Bureau of Ships concluded that hydrofoil technology had progressed far enough to warrant an accelerated development program. The program calls for construction of several research vessels, based on existing technology, and for basic research leading to design of the larger, faster craft.

In the shipbuilding phase, the Navy has contracted Boeing Airplane Co for a 110-ton-displacement patrol craft. Scheduled for service in 18 months it will be fully equipped for combating subs. It will have a dual propulsion system consisting of a 600 shp diesel engine for hullborne operation in harbors, and two gas turbines, each rated at 3100 shp, for foilborne operation.

This craft will give practical experience with a full-scale vessel, operating on flat, fully submerged foils. (The foils, similar to an aircraft wing, are joined to the hull by a right-angle strut.) Most hydrofoils today have a surface-piercing foil system. Such foils have the advantage of being intrinsically self-stabilizing, but they can't maintain speed in rough water. (When a wave hits, some dry foil area goes under water. This gives the foil more lift to climb over the wave. When the vessel rolls, one of its foils moves deeper into the water. The increased lift automatically compensates for the roll. This response is neat, but makes a rough ride in heavy seas.) The Boeing craft will use an aircraft-like autopilot for stabilization. The autopilot will measure the distance of the craft from the sea and automatically adjust flaps on the foils to get just enough lift to pass over waves.

Late this summer, the Navy will also contract for a somewhat larger, 300-ton-displacement craft. It will probably be constructed jointly by a shipbuilding and aircraft company chosen on the basis of technical proposals recently filed with the Navy. A heavily instrumented vessel, it will originally be fitted with foils designed for subcavitating speeds but its hull construction and power plant will be capable of higher speeds, so the craft can later be fitted with foils for supercavitating speeds. The Navy also recently contracted for a 15-ton craft which will be used to study the forces and stresses acting on different types of foils and struts, arranged at different positions on the hull. It will be driven by a jet fan and be capable of 100 knots.

SUPERCAVITATING RESEARCH

In its basic research, the Navy has lined up nearly all the hydrodynamic facilities in the country to study the problems anticipated with high-speed

craft. Such craft, for example, may run into hydroelastic problems, similar to aeroelastic problems (flutter, for example). But aircraft experience is not directly applicable to hydrofoils. Southwest Research Institute is working on this.

Hydrofoils are using aircraft powerplants for propulsion. Present concept is to couple very large jet engines to a free turbine, which then becomes the prime mover. Engines now being used on hydrofoils develop up to 20,000 hp for brief periods during "takeoff." The Navy is hoping for 30,000-hp engines soon, but they must come as a result of aircraft developments. The Navy can't afford a special program for hydrofoils.

Another problem is power transmission. Hydrodynamically, the cleanest way of getting power to propellers is through two right-angle bevel-gear drives at top and bottom of the strut. But there is some question whether such a system can transmit all the power required. Alternatives would include water jets, air propulsion and hydraulic transmission. Propellers will probably be of supercavitating design operating at high rpm with controllable pitch. At present, controllable pitch propellers are not available at the speed and power range the Navy is seeking.

The foils for high-speed craft will probably be superventilated, ie, air will be purposely led into the cavities that form over the foils. It's difficult to keep foils from being accidentally ventilated, hence, present thinking is to design them to take advantage of atmospheric air. The Univ of Minnesota is among those studying the mechanisms of superventilation.

HOW IT FLIES

Practical experience with a small supercavitating craft is being provided by the SCH-6 Sea Wings, designed for the Navy by Grumman Aircraft's subsidiary, Dynamic Developments. Built before the Navy accelerated program got underway, its hydrofoils consist of two surface-piercing units in front of the craft's center of gravity and a submerged foil at the rear. Front foils carry 77% of the weight. The craft is about 23 ft long with foils extended.

During flight, cavities form over the upper surfaces, behind the blunt base of the foreward foils and along the rear sides of the struts. They also form behind the blunt base of the tail strut. Elsewhere, flow is subcavitating. The foils are ventilated by forcing air through tubes to the bunt base of the tail strut and to the trailing edges of the diagonal cruise foils. This air originates at two bleed ports behind the compressor section of the gas turbine power plant. In addition, paths for the air flow from the atmosphere are provided by the surface piercing struts.

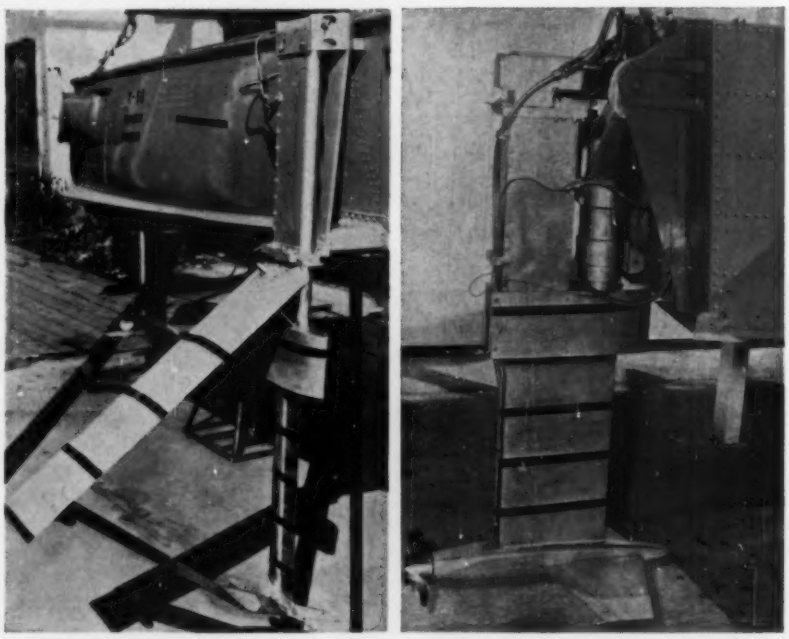
Later this summer, Grumman will launch its second major hydrofoil venture—the HS Dennison. Under contract to the Maritime Administration, the Dennison is the result of parametric and design studies carried out by Grumman with Maritime support since 1955. The craft will be 104 ft long, 23 ft in the beam and will have two subcavitating, surface-piercing front foils and a fully-submerged rear foil.

The front foils for the 60-knot craft will bear about 85% of the vehicle weight; the tail foil the remaining 15%. Dynamic lift required by the rear foil is reduced about 6000 lb because of propeller pod buoyancy. The foils can be retracted for shallow water cruising by hydraulic cylinders with mechanical linkages. Foreward foils and struts are steel; the rear foil, aluminum.

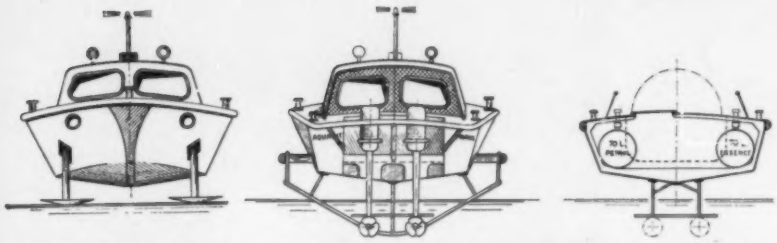
Ship's trim, when foilborne, will be maintained in part by changes in wetted foil area. But also, the foils have hydraulically operated flaps to adjust for heave, roll and pitch. Heave is sensed by an accelerometer whose signals deflect the front foils. Pitch is sensed by a vertical gyro whose signals deflect rear foils. And roll is corrected by deflecting one or the other of the front flaps. Direction is controlled by a rudder in the tail strut.

The craft has two engines: A 765-hp gas generator and free turbine combination with integral gearbox for displacement operation. The other is a gas generator and free turbine, developing up to 16,800 shp for foilborne operation.

Thrust for foilborne operation is provided by a 3-blade supercavitating propeller, 36 in. dia. At optimum



HIGH-SPEED FOIL system for Grumman's experimental Sea Wings is designed to operate at supercavitating speeds. It includes an underwater cruise foil, whch is attached to a diagonal foil and a strut. The diagonal foil gives lift at low speeds. The cruise foil has a curved underside, flat top, sharp leading edge and blunt trailing edge—a configuration that allows formation of a steady cavity above it. The diagonal foil is of subcavitating design and flat bottom and rounded top and rises clear of water at high speed. The strut has parabolic forebody and tapered afterbody. Tail foil of the Sea Wings is of subcavitating design. It has an elliptical leading edge and tapered rear, and is mounted on the foreward half of the propeller pod. The propeller is a three-bladed supercavitating design by David Taylor Model Basin. It is 10 in. in diameter.



AUTO-STABILIZING WING SYSTEM, another foil configuration, is the design of International Aquavion of the Netherlands. It includes a main surface-piercing foil, just behind the center of gravity; a stabilizing foil at the rear and two small wings at front. The main foil stays underwater. The rear foil is fully submerged and helps check pitching. The two front wings plane on the water surface, carrying about 15% of the craft's weight. In rough water, they provide reserve lift when the sea circulates around them.

efficiency it produces 25,000 lb thrust at 2670 rpm for foreward speed of 60 knots. Thrust for displacement operation is provided by two water-jet propulsion units, consisting of a 3-stage axial-flow pump capable of 7500 gpm. They can give reverse, foreward, and neutral thrust. The jets are diverted through a 41-deg angle to port or starboard to steer the craft.

DEVELOPMENTS ABROAD

Abroad, hydrofoil technology is moving fast. The Soviets have announced that they are putting the finishing touches on a hydrofoil called the Sputnik. It will carry 300 passengers at 40 to 60 knots. The Sputnik was preceded by two smaller vessels, the Rocket and the Meteor. The latter is said to carry 150 passengers at 40 knots. The Soviet vessels are all diesel-powered, though one version of the Sputnik will have a gas turbine. They are seen as a means of carrying passengers and cargo over Siberia's rivers.

In Japan, Shin Meiwa Industry Co, Ltd has recently launched a hydrofoil of its own design after 7 years of research. Originally, the company wanted a boat for testing marine aircraft engines in waves. The hydrofoil seemed desirable because it leaves no wake. The Japanese craft travels at 40 to 50 knots, powered by a 225-hp Chrysler or Gray marine engine.

Among the most advanced of the foreign hydrofoils, is the vessel designed by Hans von Schertel in Germany before World War II and first tested for passenger service on Lake Maggiore, Switzerland in 1953-54. This craft is now being manufactured by Supramar AG in Switzerland and its licensees in Sicily, the Netherlands, Norway and Japan. Two of the models (one for 72 passengers, the other for 140) are now in passenger service in European water. A still larger model (a 120-ft craft for 200 passengers) is under construction.

The Supramar craft have two foils in tandem—one under the bow, the other under the stern. The bow foil is V-shaped and bears 55 to 75% of the load. The rear foil is hexagonal with only its lower half submerged during flight. The foils have no stabilizing flaps, depending entirely on the corrective forces of wetted-foil area. The company is now working on fully submerged foils.

The new 200-passenger craft will do away with the long propeller shaft that's found on the smaller models. Instead, it will use a Z-drive with double bevel gears. It will be powered by two Briston-Siddely "Proteus" gas turbines, and will have a 200 hp auxiliary power plant for maneuvering as a displacement craft.

In the Sicilian-made products (the Rodriquez Shipyards have made many of the ships now operating) hull is made of aluminum-magnesium alloy plates and aluminum-magnesium-silicon alloy frames. The hydrofoils are a special steel, and the 3-bladed propellers are bronze with stainless steel shaft, and steel intermediary shaft driving through a universal joint to gearbox and steel propeller tube.

The Dutch have also designed a hydrofoil craft. It differs from the other systems in that ship weight is borne predominantly by the rear foils. The foil system, called an auto-stabilizing wing system, consists of three units: a main foil, just behind the center of gravity; two small front wings; and a rear stabilizer (see drawings).

—Dora Merris, assistant editor

RETRACTABLE FOILS of this craft are designed by Shin Meiwa Industry in Japan. They include surface-piercing forward foils and fully submerged rear foils. The propeller shaft is retractable. The craft is made of aluminum

Tapered-profile spring makes debut in cars

DETROIT—Something new will appear on at least one automobile when the 1962 models are introduced: a single-leaf, tapered-profile suspension spring. It is scheduled to appear on the new Chevrolets. But all the other automobile companies are investigating it. It is new only in the sense that this will be the first passenger car to use it.

There is a long history behind the taper spring. It started in 1938, when engineers of what is now Rockwell-Standard Corp began to study the possibility of substituting a single-leaf spring for the multileaf assembly then common to all American car suspensions. This work developed from a single-leaf, uniform cross-section spring tested as a transverse member of a front suspension, to a single leaf tapering in width and thickness toward both eyes, to one of uniform thickness and tapering width, to the current final design in which the

continued on page 20

The Westinghouse man with the motors brings you—

New Class B Insulation to give you 15% more horsepower on totally-enclosed Life-Line motors

Now Class "B" Insulation replaces Class "A" *as standard* on totally-enclosed 1-250 hp Life-Line a-c motors giving you these advantages:

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J-22170

width of the spring is uniform, and the thickness tapers from the center section to both eyes. The new tapered spring is already in use on some trucks —not made by the big three—in two- and two-and-a-half leaf designs.

While the Chevrolet manufacturing process is not known, Rockwell-Standard springs are produced by roll forging a blank in a die in a single rolling operation. Heat treating, removal of decarburized layer, and shot peening complete the operation. Tapered springs so produced are said to have close uniformity of properties and performance, and a long service life. The single-leaf tapered spring is said to be much lighter than the stacked spring it is designed to replace, and to be producible at lower cost.

–Felix Giordano, Regional Editor

Design problems stall radiotelescope construction

WASHINGTON—Design snags may force the Navy to cancel its big 600-ft dia radiotelescope at Sugar Grove, W. Va. Trouble-ridden from the start, a final design of the facility, started three years ago, still won't be ready until next year.

Meanwhile, cost of the program has spiraled from the original $79-million estimate to nearer $180 million. And need for the radiotelescope reportedly has decreased because of success in bouncing signals off the moon and introducing navigation and communications satellites for long range communications. These factors are compelling the Navy to consider cancellation of the project–a decision that, if made, will cost about $67 million.

WEIGHT THE PROBLEM

Conceived as the world's largest moveable structure, the huge telescope was originally planned for design in increments—just ahead of construction progress. But, as design progressed, total weight increased about 50% over the original estimates of 28,000 tons.

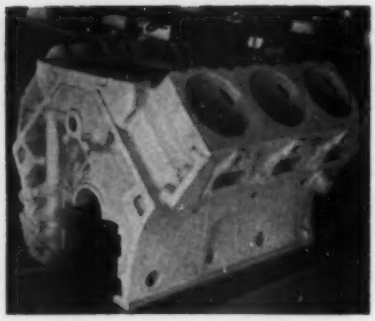
This halted construction until all elements could be redesigned or strengthened to compensate for added weight. The squabble over design of the structure reached a peak last fall when the Navy canceled its design contract with Grad Urbahn and Seelye and placed it with Ammann & Whitney, both of New York. Since then, virtually no progress has been made on erecting the structure. Completion time is now estimated at late 1964—over 2 years behind the original date.

A Navy decision to cancel or continue the project will come in the next few weeks because additional funds must be committed to the project by then. ■

Aluminum on upswing in European production

VIENNA—Europe is reviving interest in designing with aluminum and is pushing the research necessary for better alloys, processing and fabrication techniques. This trend was underscored at the International Metal Conference here, attended by some 600 delegates from 18 countries.

Though Europe produced about 50% of the world's aluminum before World War II, it ceded leadership to the US thereafter and now accounts for about 19% of total production. But production is again on the upgrade, according to R de Vitry, president of the Pechiney Co, Paris. In 1950, Europe consumed 338,000 metric tons, but in 1960 it consumed 1,330,000 metric tons–a growth rate of about 7.2% a year.

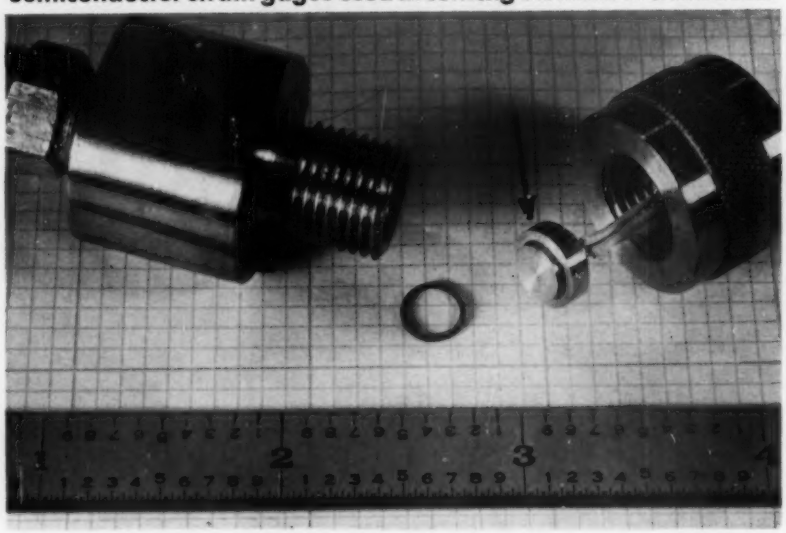


LARGE ALUMINUM ENGINE BLOCK for a 6-cylinder diesel with 19:1 compression ratio was among exhibits at Vienna's Light Metals Conference. It was cast for the Maschinenbau Institute of Graz.

Europe now has 10 major producers who together turn out 932,000 metric tons. Expansion programs are underway in Norway, Germany, France, Greece and Italy for an additional capacity of 400,000 metric tons. Eventually, European demand is expected to reach 2-million metric tons annually.

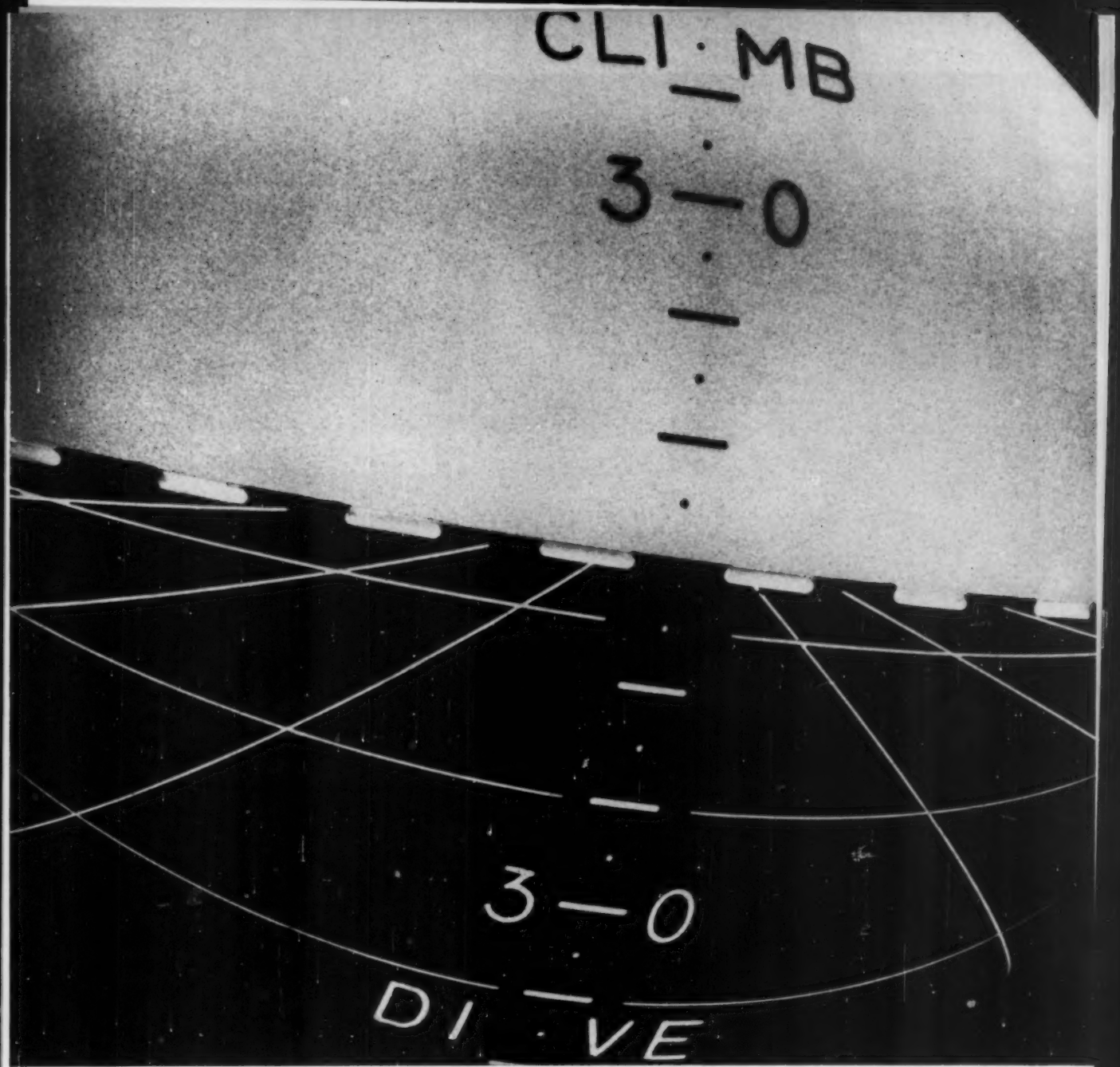
–Fred Baer, Regional Editor

Semiconductor strain gages used in sensing element of transducer



Major advances in pressure-transducer technology are claimed by Micro Systems Inc, San Gabriel, Calif, for its miniature unit (arrow). Transducer uses semiconductor strain gages in the sensing element and is available in pressure ranges from 50 to 500 psi; new series will range from 25 to 1000 psi. The pressure sensing diaphragm is 0.25 in. dia and the mounting flange is 0.35 in. It is less than ¼ in. long. Frequency response is nearly triple the normally expected rate; 100-psi-range unit responds at 40,000 cps rate, 500-psi unit at 70,000 cps. All can operate with repeatable results between –65 F and 250 F. Full-scale delta emf with a half-active bridge and 6-v input is 200 mv. With a fully active bridge and 12 v input the delta emf is 1.0 v; sufficient to drive most meters and many recorders without amplification.

CIRCLE 21 ON READER SERVICE CARD→



Lexan resin provides dimensional stability in close-tolerance parts

Maximum change allowable in the overall dimensions of this five-inch attitude indicator component is only 5 mils over a temperature range of –65° to 300°F! Moreover, the aircraft instrument part must maintain these tolerances under conditions of high humidity. To meet these severe requirements for dimensional stability, Lear, Inc. selected **LEXAN** polycarbonate resin.

In addition to high performance, **LEXAN** offers easy and versatile fabrication. Thermoplastic, it is injection molded in half spheres which are joined by solvent cementing. After lathe turning to insure complete accuracy, the spheres are painted three different colors. Maximum visibility is obtained by lighting from the inside. With their high temperature resistance and high impact strength, these polycarbonate spheres are both rugged and precise design elements. They are fabricated for the Instrument Division of Lear, Inc. by Monroe Industries — both of Grand Rapids, Mich.

This component is an example of what high-performance **LEXAN** polycarbonate resin can do for your designs. The price of the resin has gone down, too, as production has gone up. Can *you* afford to overlook the major advantages of this new, major design material? Send for design literature.

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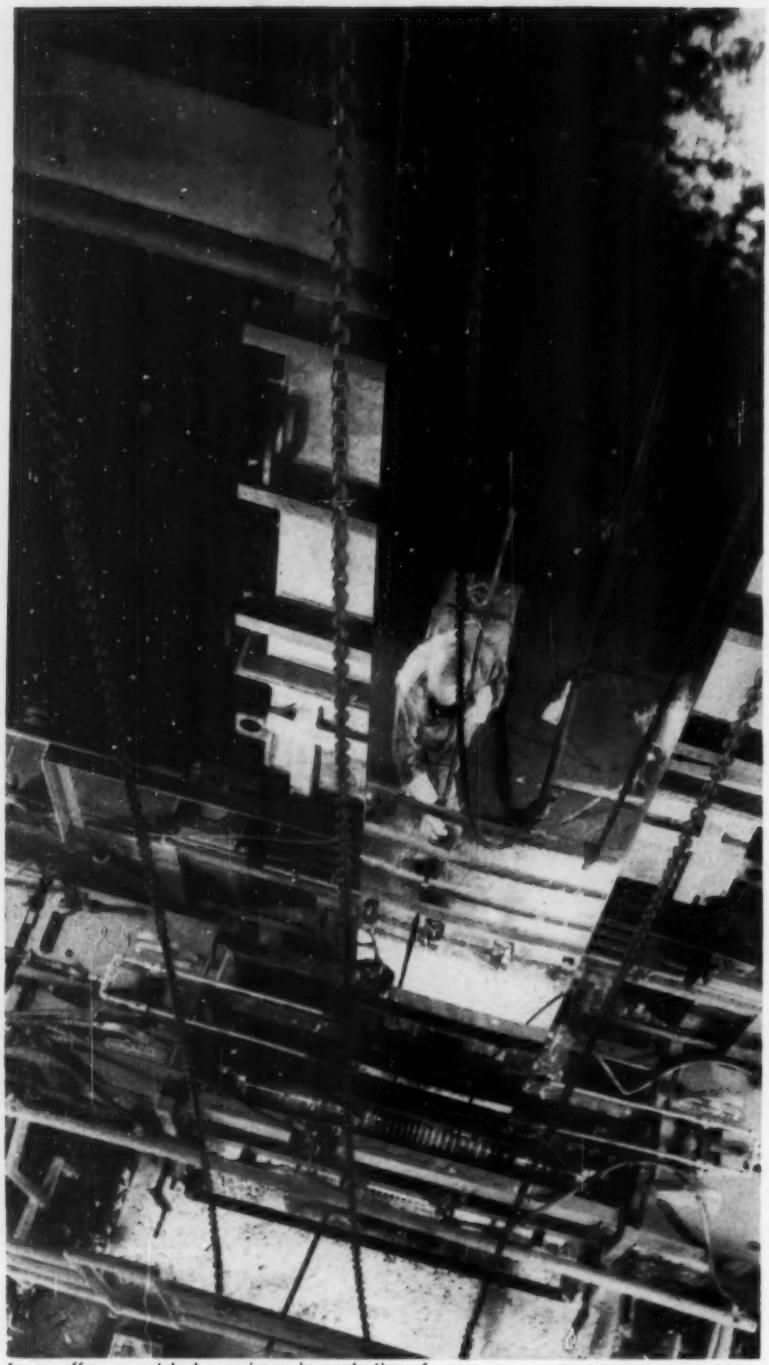
Chemical Materials Dept., Section PE 71, Pittsfield, Mass.

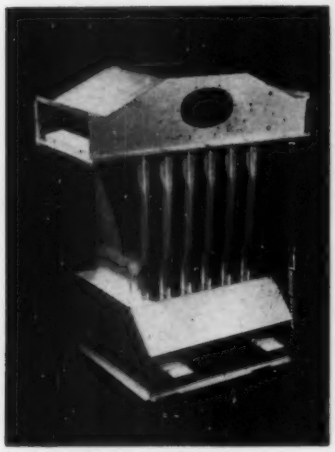


Armco offers unmatched experience in production of continuously zinc-coated and aluminum-coated steels.

Armco Offers

In 20 gage, 36-inch width, zinc-coated and aluminum-coated sheet steels produced by Armco would circle the earth more than 26 times!

Three varieties of Armco zinc-coated steel were used in these auto parts.

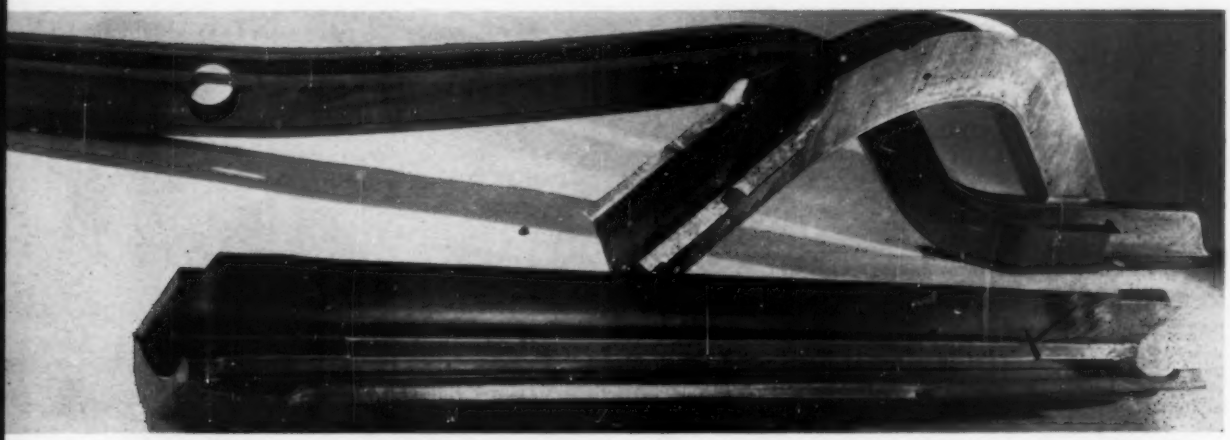


Heat-resisting parts, like this heat exchanger, serve longer when made from Armco ALUMINIZED STEEL.

Use this modern symbol of strength, economy, durability

Steel

633,000 "Miles of Experience" in Coated Steels



Quantity is one measure of experience. *Job-tailored quality* is another. It's the result of Armco's continuing refinements and innovations in practices for production of coated steels to meet specific needs. For example, consider Armco ZINCGRIP®, the original (1936) continuously hot-dipped zinc-coated steel. Today, it provides zinc protection and workability for hundreds of manufactured products. In addition, ZINCGRIP has taken on new dimensions—both figuratively and literally. Depending on gage and width, you can order varieties with or *without spangles*, and to speed production of painted parts, with mill-applied paint-holding surfaces. In 12 through 20 gage, ZINCGRIP also is now available in the widest hot-dip zinc-coated sheet produced—72 inches.

Two aluminum-coated types

For products requiring special kinds of durability, there are two Armco-developed hot-dip aluminum-coated steels. ALUMINIZED STEEL Type 1 provides low-cost resistance to combinations of heat and corrosion. Type 2 gives products outstanding life outdoors.

Measure quality of Armco's service-proved coated steels yourself. They're made to perform well—in production and in products. Mail the coupon for complete information.

New steels are born at Armco

Armco Division, Armco Steel Corporation
2041 Curtis Street, Middletown, Ohio

PLEASE SEND information on ☐ Armco ZINCGRIP ☐ Armco ZINCGRIP PAINTGRIP
☐ Armco ZINCGRIP A (spangle-free) ☐ Armco ZINCGRIP A, PAINTGRIP
☐ Armco ALUMINIZED STEEL Type 1 ☐ Armco ALUMINIZED STEEL Type 2

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ARMCO **Armco Division**

POINTS OF VIEW

THE QUESTION: *Where are your biggest*

"The demands of today's weapons systems . . . have some impact on the Engineering/Purchasing relationship. However, this impact is often overstated. The problem stems mainly from the fact that many 'state-of-the-art' components have to be procured and these components have to have extremely well-controlled specifications. This results in a continual evolution of the engineering specifications and redefinition of the product's characteristics, depending upon the vendor's performance. This evolution occurs in the procurement cycle. To minimize the problems that result requires a very close Engineering/Purchasing working relationship and requires engineers who are sensitive to procurement problems and purchasing agents who are sensitive to engineering problems.

"We meet this requirement by selecting competent personnel with broad perspective and by holding frequent purchasing, engineering, product reliability and supplier conferences for a face-to-face solution on the spot."

A V Sommer
Chief engineer
American Bosch Arma Corp

Nicholas P Roth
Chief engineer & purchasng agent
George K Hebner Inc, Philadelphia

"The PA should know nothing about engineering . . . and follow the specifications to the letter, taking no variations or deviations from the specifications. Or he should be a fully trained engineer, who can carry out the intent—if not the letter—of the specs economically. A purchasing agent without adequate engineering training gets lost in the highly technological business world we're living in today. He cannot interpret plans and specifications properly on certain items that are to be bought. Therefore he is in danger of falling into a salesman's trap.

"A purchasing agent can actually help an engineer because he knows a great deal more about the sources of supply for the great detail of articles that may be brought into a particular business. The engineer can then assimilate this information and decide what is the most economical for his particular needs. Then, the engineer can direct the PA to buy from the particular source.

"Engineers can help PAs by being very specific and writing clear, concise specs. Specs should be written so that anyone who wants to bid on the particular item has no questions in his mind concerning exactly what is required.

"Above all, the PA should not buy on price alone. In our business, the engineers rarely specify a particular manufacturer or supplier. The buyer-engineer does this. If our engineers do specify a particular item they add the words 'or equal.'"

problems with purchasing agents?

"There is a problem in communication . . .
with the purchasing agent. He is responsible for spending his company's money in the most effective manner, and it is understandable that the purchase price will weigh heavily in the final selection of source. However, in many cases, price is given too much consideration. This is particularly true if the purchasing agent is not 'customer oriented' as to the total value aspects of his own company's product line. Our problem is to show him what his dollar buys—in full. Further complicating this part of the picture is the fact that we are often twice removed from the end user, our customer's customer. So these 'value' features may not be as highly regarded by the purchasing agent as they are by his own company's customers.

"An inherent problem in marketing highly engineered products is effective selling of total value. This includes such things as quality and reliability, continuity of supply, application assistance, full-life field service, and customer training. To measure the merits of our products versus those of our competitors calls for a thorough technical appraisal of product specifications and performance, plus these related factors. At the time of contact with the purchasing agent, these 'fringe benefits' are basically intangible and not so readily evaluated as specifications on capabilities, speeds, pressures, etc. It is difficult to convey a full appreciation of product capability as it applies to a specific job."

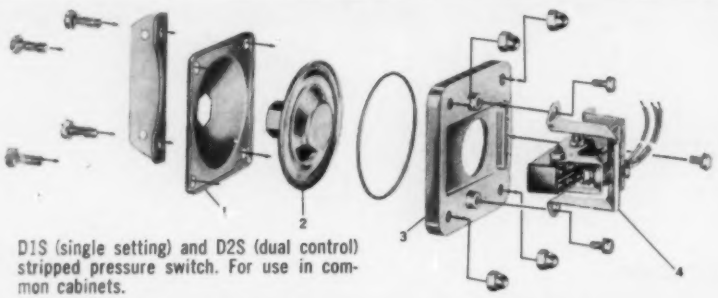
William F Driver
Marketing manager
Machinery Hydraulics Div
Vickers Inc, Div of Sperry Rand

D F Craig
Vice-president
Coleman Engineering Co Inc
Torrance, Calif

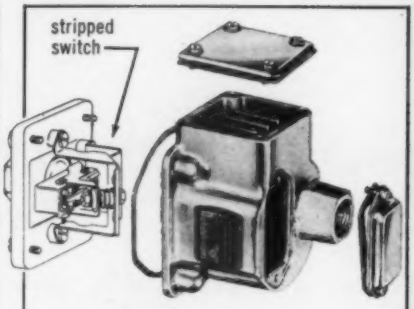
"In the handling of R and D projects . . .
they generally lack the grasp of the technical requirement, they are devoutly steeped in procedure, and they continually look for the cheapest dollar procurement regardless of quality, delivery or reliability.

"Pessimistic as this may sound, I feel that these conditions can and will improve if purchasing agents are raised above a clerical level to professional standing, are especially picked for and educated in the technological requirements of their area, and are given the latitude to buy quality equipment for the specific task rather than accepting the easy out of the low bidder. This uplifting and upgrading will improve the position of the purchasing agent who constantly struggles to please too many people without the proper technical information, proper policies or the proper support of the agency he is trying to service."

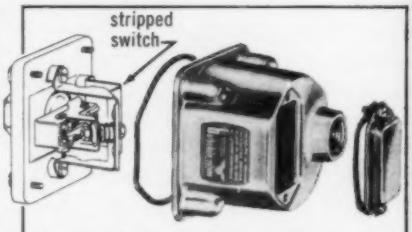
How to put 50% more accuracy into a pressure switch at 25% lower price



D1S (single setting) and D2S (dual control) stripped pressure switch. For use in common cabinets.



D1T (single setting) pressure switch with integral terminal block. Weatherproof housing.



D1H (single setting) and D2H (dual control) pressure switch with standard housing. Weatherproof.

The accepted standard of accuracy in pressure switches is ±1%. The new Barksdale diaphragm pressure switches are guaranteed for ± ½ % set and re-set accuracy (±0.2% if required). This instrument accuracy, unique proof (test) pressure characteristics, and remarkably easy servicing are accomplished by the use of a "basic unit" diaphragm assembly to which components are attached as required. The erector set principle permits production economies that are reflected in substantially lower prices. The entire concept of Barksdale pressure switches is the result of desired specification improvements as suggested by representatives of varied industries who were consulted before designing was begun.

The versatile basic unit

A leakproof, welded-metal sensing element (No. 2 in the photograph above) is surrounded by a heavy protective capsule (Nos. 1 and 3) which is independent of the sensing and switching elements. The hex of the pressure connection fits into a hex opening in the base of the capsule, preventing damage to the diaphragm should the unit be twisted during installation or removal. The standard pressure connection is ¼" npt female pipe fitting; ½" npt fitting is available when specified. The latter was requested by the petroleum industry to facilitate removal of paraffin accumulation and to permit attachment of switches directly to ½" pipe.

Diaphragms easily removable

Diaphragms may be removed without disturbing switch wiring, thus making it possible to change diaphragms to accommodate varying pressure requirements or to substitute diaphragms of different metals as fluid characteristics may demand. This feature cuts inventory costs for original equipment manufacturers because they need stock only diaphragms to meet their various pressure requirements rather than to stock complete switches in every category. It is important, also, to the petroleum industry because only diaphragms (not entire switches) need be carried by personnel doing field service.

Proof (test) pressures to 300 psi

The upper and lower sections of the diaphragm capsule are molded to fit the sensing element exactly. The top section prevents the diaphragm from stretching beyond normal curvature when surges above system pressure are encountered, and there is no possibility of metal distortion that would affect switch accuracy. In the low settings the new Barksdale pressure switches will actuate at 0.1" mercury with proof (test) pressure to 10 psi. In higher ranges they will go up to 300 psi proof (test) pressure at settings to 150 psi.

Stripped switch (single and dual control)

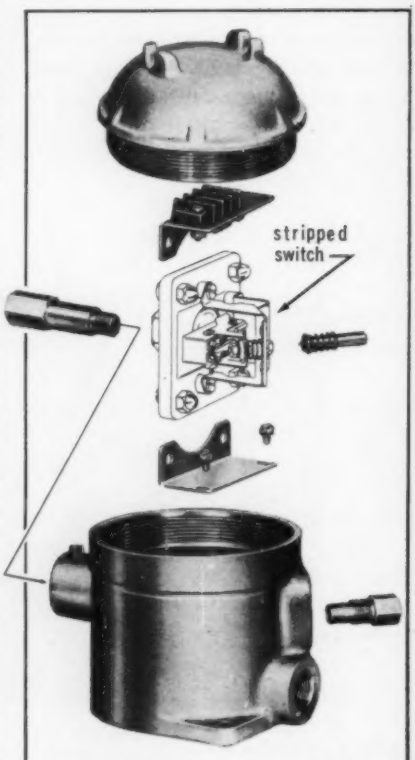
Addition of a switching element (No. 4 above) to the basic diaphragm unit makes a stripped switch for use in a common cabinet with other electrical devices. Original equipment manufacturers need not pay for unneeded housings. Extremely fine adjustment is possible because the adjusting screws have 64 threads to the inch. Adjustment may be made with a screwdriver or a wrench.

Housings added to suit

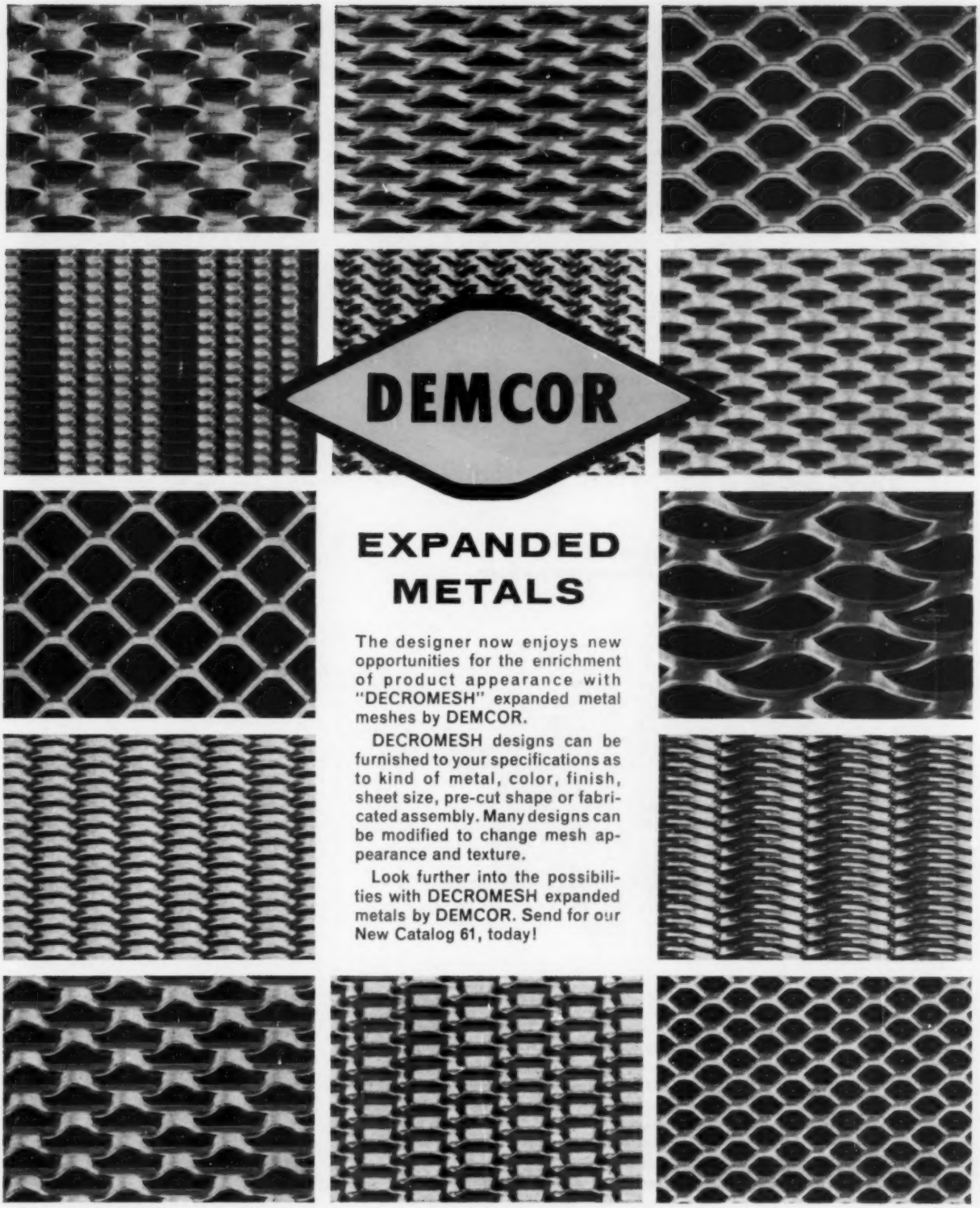
Addition of a sealed housing (standard, terminal block, or explosion proof) to a stripped switch completes a pressure switch that can be ordered "tailor made" for any desired application. In the standard housing, free wire leads are through a ½" nps conduit conductor. Wires are held firmly in place by a special tension clip that prevents disturbing the switch adjustment through careless wire handling. Terminal block housings are available for wiring convenience. Pottable electric outlets and external adjustment on explosion proof housings were suggested by the petroleum industry. Servicing instructions on all Barksdale switch housing are on the inside of a tamper proof cover to allow for painting of units.

Ask for new catalog

New Barksdale diaphragm pressure switches offer you something new in accuracy, proof (test) pressure, and economy. The just-printed catalog tells the complete story. Ask your Barksdale representative or write to Barksdale Valves, 5125 Alcoa Avenue, Los Angeles 58, California.



D1X (single setting) and D2X (dual control) explosion proof pressure switch. Pottable electric outlets. External adjustment.



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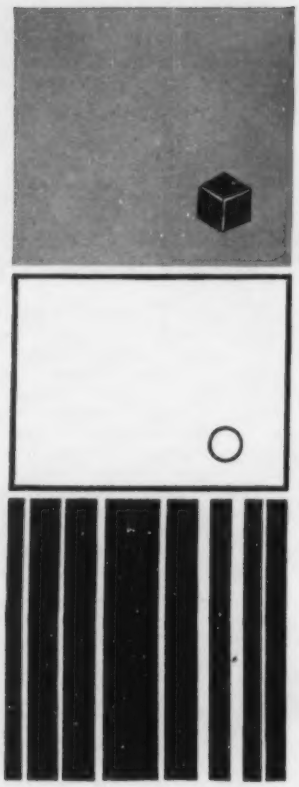
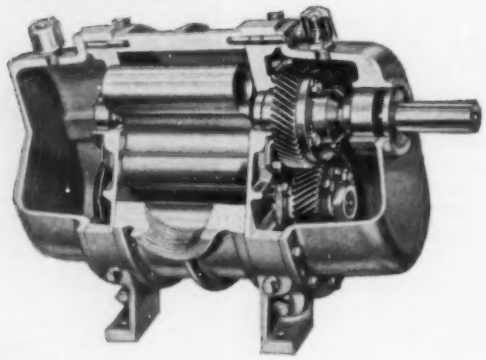
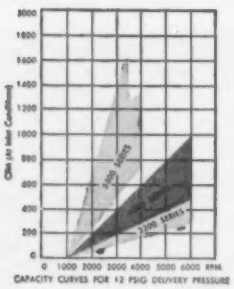






WITH M-D 3-LOBE BLOWERS

If space and weight of the blower is a concern in your design problem, consider this fact. M-D rotary positive blowers because of their unique 3-lobe design require smaller cubic space than any other blowers. A survey shows that a 14 PSI M-D takes 3/4 to less than 1/10 the space of competitive models . . . and in some cases are only 1/10 the weight.

M-D Blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 30 production models range from 30 to 4000 CFM, pressures to 15 PSIG single, 70 PSIG multi-stage.

For full information write

M-D BLOWERS, INC., RACINE, WISCONSIN

A SUBSIDIARY OF MIEHLE-GOSS-DEXTER, INC.

READER TO EDITOR

Does the editor have a ghost writer?

To the Editor:

Having been married to an engineer for almost 29 years, I've acquired a bit of interest in the way engineers think and do things. Recently I flipped through the pages of the SAE Journal (June 61, p 32) and read Mr. Tangerman's article "The engineer is a threat to society." It's perfect. Engineers are delightfully different at times, and an exasperating breed of humans. However, I would almost guess that a man did not write the article. I'd wager an engineer's wife did. Does Mr. Tangerman have a "Mrs Ghost Writer?" Incidentally, my definition of an Engineer —"a man who has a problem for every solution." Thanks for giving me so much reading pleasure. —HARRIETT P LIDDELL

Springfield, Penna

• You lose your bet, Mrs Liddell. The article in the SAE Journal was taken from a speech written and delivered by Editor Elmer Tangerman at the SAE Central Illinois Section, Earthmoving Industry Conference. His wife and his secretary both read it, but only under pressure. If any reader wants a copy of the speech, write to PRODUCT ENGINEERING, Reader Service, 330 West 42 St, New York 36.— *Ed*

Humming instrument

To the Editor:

In your issue of May 1, p 32, under the section "Why Don't They R & D?", Mr. C Perko asks for an electronic musical instrument that could be played by anyone who can hum a tune. There is already a patent granted to Mr John Hanert for a monophonic instrument that transforms hummings into sounds resembling several instruments.

The humming picked by the microphone must be shaped to a more-or-less pulsed waveform that can be used to trigger a monostable multi-vibrator. This will deliver a square waveform of the same frequency of the humming. Two or three flip-flop circuits can then divide this frequency two or three times giving the sub-octaves of the note hummed. These waveforms can then be shaped by conventional filters, giving a great number of tone colors. —LUDOVIC SZENESZI

Rio de Janerio, Brazil

Corrections

To the Editor:

Here are some editing errors in my article "How to Design the Soldered Electrical Connection," in the June 12 issue page 57 that you should bring to the attention of your readers:

1—Text states there are ten basic solders, but comparison table lists nine.

2—Table IV (Solderable Coatings) should state that for a porous gold plate over silver, the problems are the same as for silver alone.

3—Table V (Connection Design Criteria) for round-to-round, col 4,

formula is limited to 1:3 ratio; for larger ratios use col 5, as stated in text. In col 7, length in wire-to-post sketch is shown entirely too long. In last col, wire-to-post, delete 2 in formula over sketch, since 2 is seldom the best number of turns.

4—How to Calculate Joint Dimensions, p 61, should state that the relationships hold for all conductors—not just copper.

5—Photo captions on page 63 should state that the left-hand joint in photo C (lower left photo) is the one that satisfies all requirements—not the left-hand joint in D which, although it is a perfect joint, has surplus turns of wire.

6—In the last paragraph the equation for shear strength should be $A_s = 0.05 \pi D_1$. You left out pi. —HOWARD H MANKO
IBM, Poughkeepsie, N Y

COMING EVENTS

JULY

16-21 . . . . Instrument Society of America, IFME, AIEE, IRE, 4th International Conference on Bio-Medical Electronics & 14th Conference on Electronic Techniques in Medicine & Biology, Waldorf-Astoria Hotel, NYC

18-20 . . . . Western Plant Maintenance and Engineering Conference and Show, Pan Pacific Auditorium, Los Angeles

AUGUST

22-25 . . . . Institute of Radio Engineers, WESCON Electronic Show & Convention, The Cow Palace, San Francisco

23-25 . . . . American Institute of Electrical Engineers, Pacific General Meeting, Salt Lake City, Utah

28-Sep 1 . . . . American Society of Mechanical Engineers and American Institute of Chemical Engineers; Institute of Mechanical Engineers and Institution of Chemical Engineers (Great Britain), International Heat Transfer Conference, Univ of Colorado, Boulder

SEPTEMBER

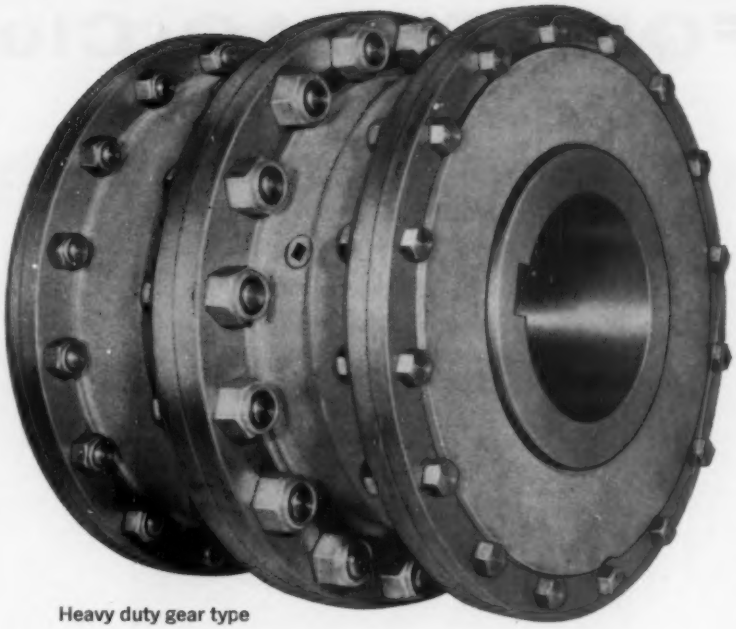
11-14 . . . . Society of Automotive Engineers, National Farm Construction & Industrial Machinery Meeting, Milwaukee Auditorium, Milwaukee Wisc

14-15 . . . . American Society of Mechanical Engineers, AIEE and IRE, Joint Societies Engineering Management Conference, Hotel Roosevelt, NYC

20-21 . . . . Institute of Radio Engineers, AIEE and ISA, Industrial Electronics Symposium, Bradford Hotel, Boston

25-28 . . . .American Welding Society, Fall Meeting, Adolphus Hotel, Dallas, Texas

For a listing of addresses of societies and associations send 25¢ to Product Engineering Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R 32.



Heavy duty gear type

Up to 6,000 hp per 100 rpm

Here's the coupling with all the muscle you need for heavy duty slow speed mill drives. The machined surfaces of each high grade steel casting are given a fine tool finish within strict tolerances. Waldron mill type couplings are easy to assemble, and seal tight against dust, moisture, and loss of lubricant. The standard sizes listed below are available for quick delivery. Write for Data Sheet S-1050.

Size and nominal bore	HP/100 rpm	Max. rpm
7	1,282	1,950
8	1,912	1,720
9	2,662	1,550
10	3,675	1,400
11	4,950	1,275
12	6,000	1,200

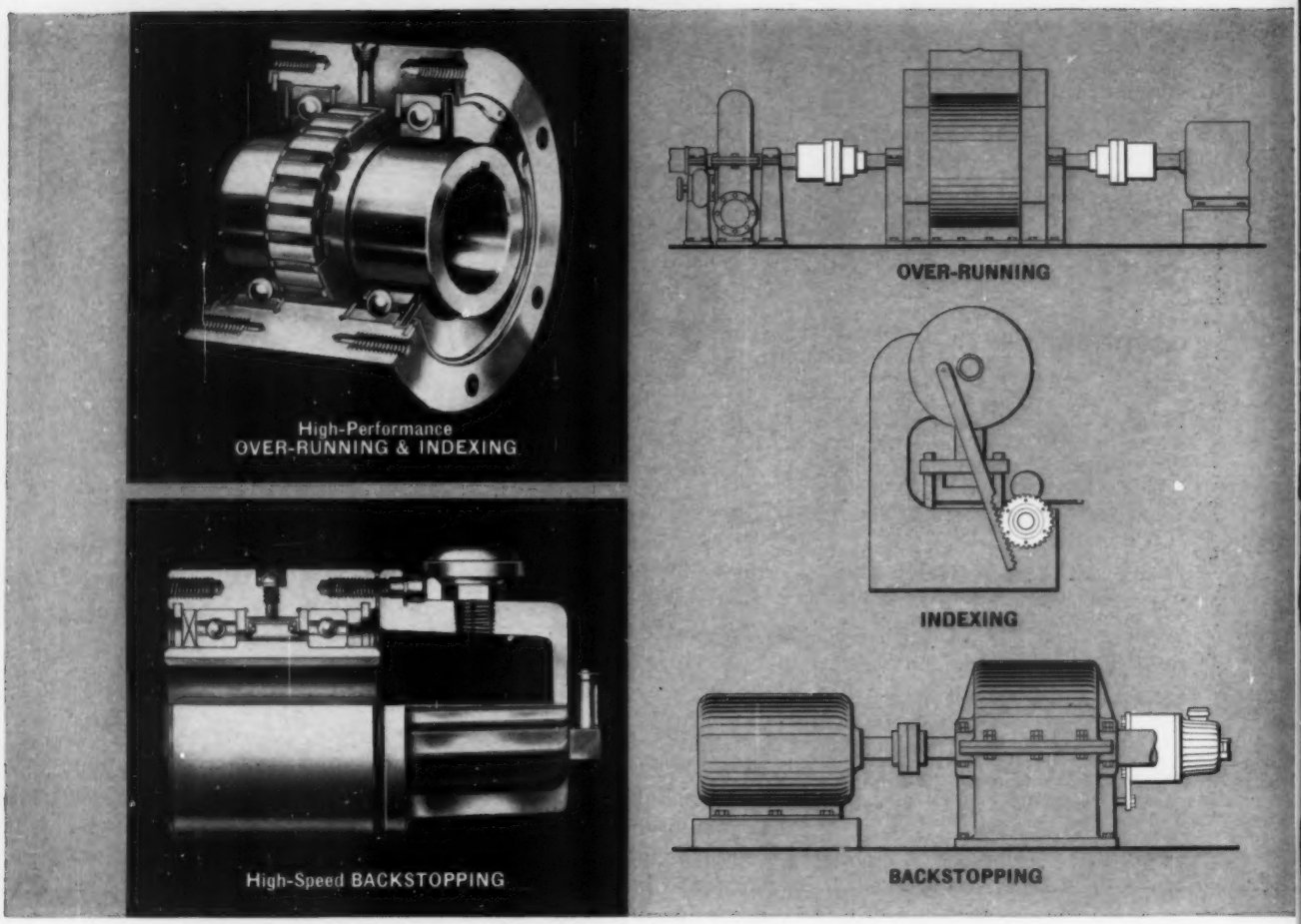
WALDRON-HARTIG, Box 791, New Brunswick, N.J.
a division of Midland-Ross Corporation MR

WALDRON
Makes it easy to pick the right

Couplings

CIRCLE 29 ON READER SERVICE CARD

FORMSPRAG Clutches have



These Installations Prove Formsprag Has The Most Advanced Clutch Designs Available

On tough applications requiring high-performance over-running, indexing or backstopping, Formsprag clutches have *proved* their unusual durability, precision and reliability. Their long-life and minimum maintenance requirements, even under unusually demanding installation conditions, have provided many users with the answer to their clutch problems. Compare the following performance results on actual installations—Formsprag designs can help you, too!

High-Performance Over-Running

Application:
Forced and Induced Draft Fans.

Clutch and Mounting:
Model FO-732 Clutch-coupling (HPO-720 clutch with coupling) mounted on fan drives.

Requirements:
Continuous over-running at 1200 to 1800 R.P.M. (24 hours a day, 365 days a year).

Proved Results:
The Formsprag HPO clutch design with Formchrome sprags provides this company with greater durability and less maintenance than any other available clutch. Therefore, on all forced and induced draft fans, this manufacturer specifies Formsprag high-performance over-running clutches.

Precision Indexing

Application:
High Speed Press.

Clutch and Mounting:
Model HPI-700 feeding a progressive die.

Requirements:
20° indexing; feed is 700 strokes per minute; accuracy of feed must be within .005″; press operates 24 hours a day, 5 days a week.

Proved Results:
After poor service life and unreliable results from other clutch designs, a Formsprag high-performance indexing clutch was installed. Result—customers requirements for accuracy were met, clutch has had a life of 80 million cycles and is still running.

proved higher performance

(GREATER TORQUE & SPEED, HIGHER PRECISION, LONGER LIFE)

During the last two years, Formsprag has announced several major advances in over-running clutch design. These advanced concepts have been widely accepted by designers of modern power transmission systems. The high performance results they obtained on over-running, indexing and backstopping applications *prove* Formsprag clutches to have the most advanced designs available.

On-the-job records *prove* these high performance characteristics: (1) Formchrome sprags, with high-hardness and wear resistance, provide exceptional durability—no other manufacturer can offer the performance advantages of Formchrome sprags. (2) The improved sprag and retainer design of Formsprag High-Performance Over-running (HPO) and Indexing (HPI) clutches permit up to 30% higher operating speeds with same life span and up to 70% longer clutch life when operated at same RPM as ordinary clutches. (3) On backstopping applications, the High-Speed Backstopping (HSB) clutch design permits higher speeds, assures longer life and reduces maintenance to a minimum.

Specific case-history data on *proved* over-running, indexing and backstopping installations is provided below. In every instance, users of Formsprag High-Performance Clutches have found the answers to problems of wear, high-speed operation, precision and maintenance.

There is a Formsprag Clutch for every application. Standard models include: sleeve bearing, ball bearing, miniature, large-bore holdbacks, and high-performance types. For special applications, Formsprag engineers will recommend a modified standard clutch or design a special. Standard clutches are fully described in the Formsprag catalog—send for your free copy.

FORMSPRAG COMPANY

23607 Hoover Road, Dept. 114-A — Warren (Detroit), Michigan

Representation Throughout The World • Precision Power Transmission Products

High-Speed Backstopping

Application:
Iron Mining (Taconite) Conveyor.

Clutch and Mounting:
Model HSB-700 clutch assembly mounted on high-speed shaft of reducer.

Requirements:
In abrasive atmosphere, clutch must over-run at 1200 to 1800 R.P.M. (24 hours a day, 9 months of year).

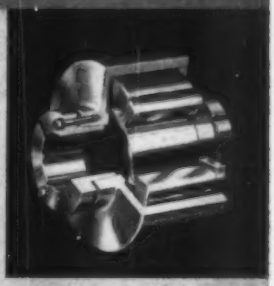
Proved Results:
On this rugged backstopping application, Formsprag HSB clutches solved problems of overheating, premature seal wear, and short clutch life. These high-speed backstopping clutches have been in operation for over a year and are still delivering their initial high performance.

OTHER FORMSPRAG PRECISION PRODUCTS

NEW RAWSON

CENTRIFUGAL CLUTCHES and CLUTCH-COUPLINGS

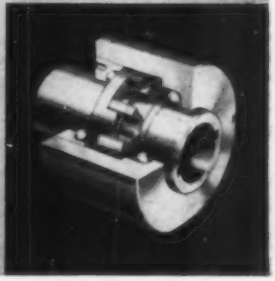
Used in a wide variety of applications, the Rawson design provides no-load starts for motors and cushioned starting of driven equipment. They permit using smaller motors and across-the-line starting.



REVLOK

DUAL TORQUE-LOCKING and POSITIONING DEVICES

These multi-purpose devices stop feedback torque and provide two-directional positioning, over-running, backstopping and load-limiting. They can also be adapted for single revolution and torque-limiting functions.



PUMP DESIGN TRENDS

ARTHUR A. NICHOLS

NEW BUILT-IN PUMP PERFORMS WELL UNDER VARIABLE CONDITIONS

► The development of three matched Gerotor pump elements that can be designed right into any mechanism requiring a pumping function, offers important design and performance advantages.

Fig. 1. Three Gerotor components permit pump to be incorporated as integral part of housing or frame of mechanism, eliminate need for purchase and mounting of separate, complete pump.

► **The Gerotor pump is a positive displacement type, delivering a predetermined amount of fluid in direct proportion to speed. It is a form of internal gear pump — simple and compact in basic design, (has only two moving parts). It is lightweight, valveless, provides exceptional performance and has low wear over a long service life. It is balanced and extremely quiet in operation.**

► Low relative speed and closely held clearances between the two Gerotor elements maintain high mechanical and volumetric efficiency.

► **Slow opening of the chamber as it traverses the large inlet and discharge ports results in avoidance of the sudden shock, rapid pressure change and turbulence which, in other types of pumps, results in foaming and lowered efficiency. Thus, Gerotor pumps offer exceptionally good performance over a wide range of inlet pressures.**

► Gerotor Insert-Packages can be designed and mass-produced to deliver up to 100 gpm and 1,000 psi within a wide range of mechanism geometry. That's because Gerotor pump capacity is a function of diameter, thickness, number of teeth and rpm of the two moving parts. These variables can be matched to just about any space restriction and capacity requirement.

► *Technical data is available. Write:*

W. H. NICHOLS CO.

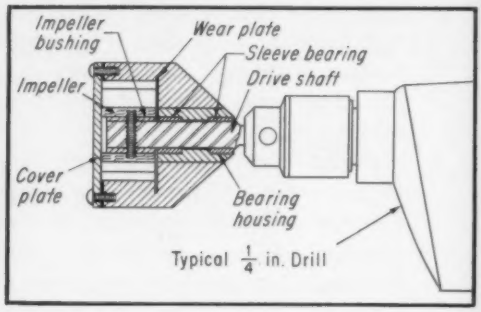
Makers of Zenith Metering Pumps and the Nichols Milling Machine "the miller that uses its head".

48 WOERD AVE., WALTHAM 54, MASS.

FOR YOUR INFORMATION (personal)

Drill becomes pump

A self-priming pump you can attach to any power tool to lift up to 6 gal./minute. That's Huber Industries' claim for its new "Liquid Lifter." The pump has a molded nylon body, fluorocarbon sleeve bearings, flexible neoprene impeller, and comes in a complete kit with vinyl and polyethylene tubing in four diameters, 5 ft of flexible discharge hose, and a spring clip. Driveshaft is stainless steel, impeller bushing and screw are brass, cover plate is aluminum. Price for the complete kit—$14.95; shipping weight, 2 lb.



Build it and fly it

Thirty dollars will bring you 30 large blueprints, and for about $1000 you have a complete kit, with everything except engine and prop, to build the Jodel D-9 shown under construction here (23-ft. wing span; gross weight, 575 lb; 80 mph. cruising speed). Or, if you prefer, you can have an autogiro. Plans, $25; Complete kit (less engine), $1995.

Falconar Aircraft, Edmonton, Alberta Canada makes the Jodel kit, offers a similar kit to build the Emeraude for about $1400. Blueprints for this one (30 of them, translated to American Standards) are $60.

The autogiro, by Saalfeld Aircraft Co, P. O. Box 84, San Diego, has a molded fiberglass fuselage. Rotor diameter is 21 ft, cruising speed 65 mph. Both companies also have 3-view brochures ($1.50 and $2.00); and supply separate kits for wings, tails, and fuselages, and assembled sections if desired. Engines are standard: Continentals and Volkswagens for the Falconar planes; a 72 hp McCulloch for the autogiro. —ARG

JODEL D-9 under construction (top), and Piel Emeraude shown complete (center), are among the planes-in-kit form offered by Canadians. Autogiro (below) is American.

first in silicones

Dow Corning

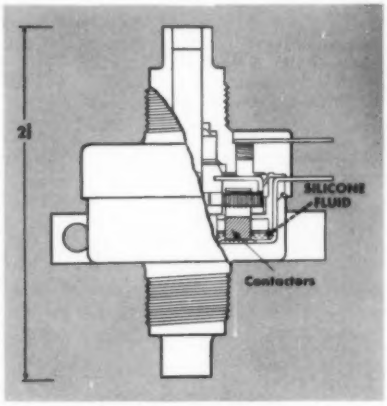
SILICONE NEWS

for design and development engineers • No. 84

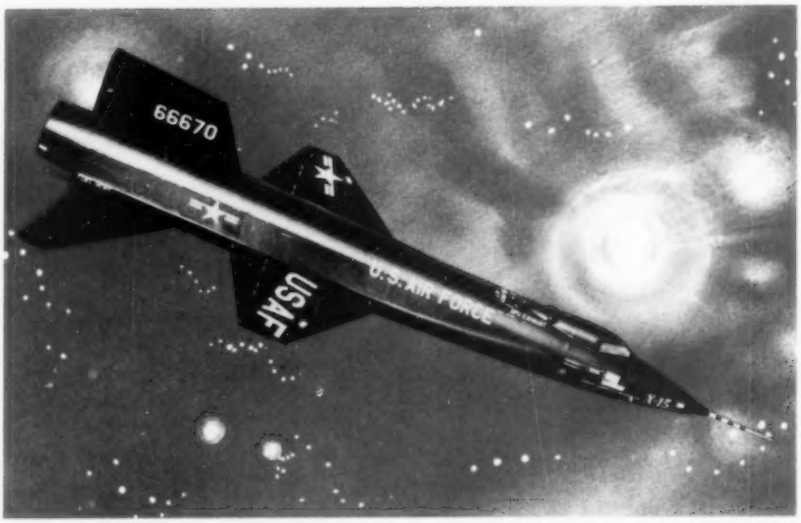
SLO-O-W MOTION

To sense extremely slow motion — or lack of motion — requires a detector that retains uniform sensitivity despite fluctuations in ambient temperatures. And that means silicones according to the designers who engineered the Micro Motion Detector manufactured by Gaylord Controls, Division of Gaylord Products Inc., Chicago. Here's how they describe this super-sensitive unit.

"Detection of motion is accomplished by a set of equally spaced hydrodynamically responsive electrical contactors driven by a common shaft. When driven at or above



a fixed speed, the contactors plane on the surface of a pool of Dow Corning silicone fluid. When shaft speed is *(Cont. Pg. 2)*



Probing Space At 3600 MPH

The X-15 provides a testing ground for both men and materials preparing for manned space flights. One of the successful materials is Silastic® LS, the Dow Corning fluorosilicone rubber that helps simplify designs because of its exceptional resistance to fuels, oils and solvents.

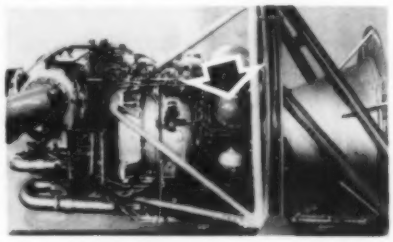
Engineers of Reaction Motors Division of Thiokol Chemical Corporation specified an accumulator diaphragm of Silastic LS for the X-15's XLR-99 engine. The accumulator provides oil at a constant pressure to the lube oil pump. Gaseous nitrogen under pressure is the source of stored energy, and is separated from 4-11V Halocarbon oil by the Silastic LS.

Here are diaphragm requirements the designers established as essential: An elastomer that—

1. **is flexible from —80 to 200 F;**
2. **is compatible with the lube oil at low and elevated temperatures;**
3. **will not contaminate lube oil.**

Silastic LS . . . the only elastomer to meet all these requirements . . . helps the X-15 as it knocks on the door to outer space.

Shown below is the XLR-99 rocket engine. The lube oil accumulator is the light weight type . . . made possible by the diaphragm of Silastic LS . . . instead of the heavy, bulky piston type. Parts of Silastic can be engineered to meet your specific needs by your rubber fabricator. For more information about oil and solvent resistant Silastic parts, circle **No. 241**



700 F PARTS MADE EASY

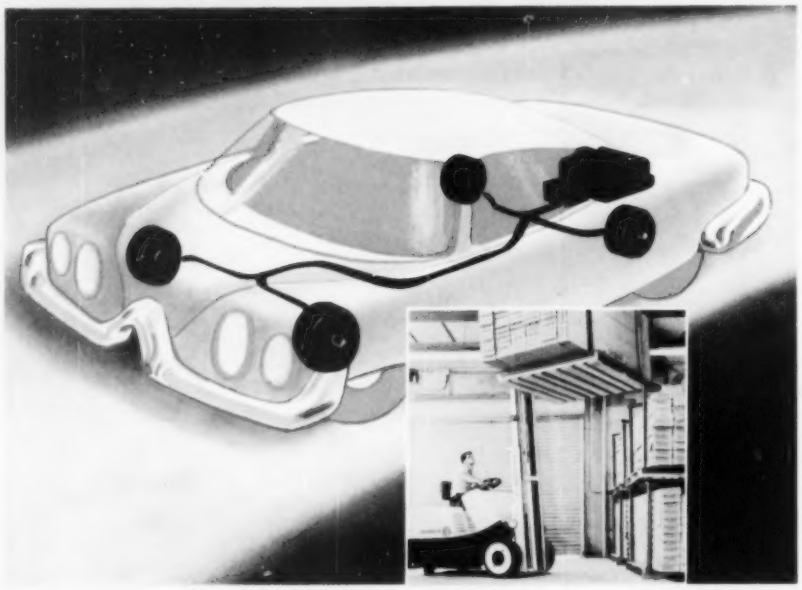
A new, thermosetting silicone compound that forms easily into rigid parts capable of 700 F service is now obtainable from Dow Corning. Designated M-6-4156, the new material makes possible high accuracy, low cost parts that are capable of withstanding exceptionally rigorous service.

Using this mineral-filled silicone molding compound, fabricators can mold parts directly into finished shapes, without costly machining. Finished parts exhibit outstanding characteristics:

- long-term dimensional stability at 700 F;
- excellent resistance to thermal shock; (from —67 to 500 F)
- low dissipation factor of 0.002 at 10^6 cps;
- high arc resistance, over 400 seconds.

Suggested applications include: fuses and fuse holders, coil forms, relay parts, tube bases, terminal parts, contactors, arc barriers, tube sockets, switch parts, and other close-tolerance ceramic parts.

Fabricators report this new *(Cont. Pg. 2)*



Electric Autos, How Soon?

Another significant straw in the wind of what may be in store for American automobile owners is presaged by introduction of a new line of electrically-driven fork lift trucks by Automatic Transportation Company, Chicago.

Current for the traction motors driving these materials handling trucks is supplied by a variable voltage generator powered by a gasoline engine. The synchronized power package supplies fast, smooth pick-up at the touch of the accelerator. The trucks are capable of traveling 8.5 m.p.h. . . . will start or stop on 28% ramps when fully loaded.

Electric propulsion has eliminated the need for a clutch, fluid coupling, fluid torque converter or multiple speed transmission. Result — lower operating costs, increased efficiency, less maintenance and potentially fewer costly repairs.

Automatic engineers place their reliance on traction motors insulated with Dow Corning Silicones because they provide greater power-per-pound and greater reliability than drives insulated with any other material. Silicone insulation provides a more generous service factor (for reliability) than is possible with any other insulating material.

If you can use more power in a smaller package, or increased efficiency with the ultimate in dependable operation, you should be looking into silicone insulated motors. Drives insulated with silicones are already at the forefront in the development of new traction motors for trucks, earth moving machines, materials handling equipment, mining machinery and locomotives. Perhaps, one day, the family car will head the list! *No. 242*

new literature on silicones

ALL NEW BROCHURE describes how Syl-off (silicone) coated papers save time and money for packagers and users of sticky products. Illustrates applications as package liners, process papers, interleaving and slip sheets. Also includes samples of coated papers plus listing of approved sources for paper products made with Syl-off coatings. *No. 245*

FIRST AVAILABILITY! ***"How Silicones Aid the Rubber Industry"*** is a production-engineering guide to the Dow Corning Silicones most useful in producing rubber and plastic materials and parts. This new eight-page manual is a concise, comprehensive reference to the ways silicones keep production on schedule, make better products, minimize scrap, speed handling and reduce maintenance and downtime. *No. 246*

Silicone Adhesives Really Stick . . . Anywhere! From —80 to 500 F, pressure-sensitive silicone adhesives withstand moisture, oxidation, weathering, corrosive chemicals, arcing, corona, and fungus; have excellent dielectric strength. Excellent for use on tapes, as sealants, spray-on coatings, bonding materials and splicing agents. *No. 247*

SILICONE COMPOUND *(Cont.)*

Dow Corning silicone molding compound is exceptionally easy to use. Even complex and intricate shapes are quickly and economically fabricated using established techniques with conventional compression or transfer molding equipment. For more information, circle . . . . . *No. 243*

SILICONE FLUID *(Continued)*

reduced, the contactors break through the fluid medium and make electrical contact with the terminal plate. When shaft speed is increased the contactors emerge through the fluid and contact is broken.

"If deceleration is at a slow rate, the contact closes at approximately zero RPM; if extremely rapid, as with a brake, contact is made a fraction of a second after zero shaft speed is reached. When the shaft is accelerated slowly, the contact opens at about 8 RPM; accelerated at a higher rate, the contact opens instantaneously."

From this description, it is quite obvious that the fluid medium must retain near-uniform viscosity over wide temperature ranges, must be oxidation-resistant, non-gumming, and must withstand shear without viscosity breakdown. That's why Gaylord engineers specified Dow Corning silicone fluid.

For detailed information on properties and applications, circle . . . . . *No. 244*

Dow Corning Corporation, Dept. 5219, Midland, Michigan
Please send me: 241 242 243 244 245 246 247

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SILICONE NEWS is published for design and development engineers by

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MIDLAND, MICHIGAN

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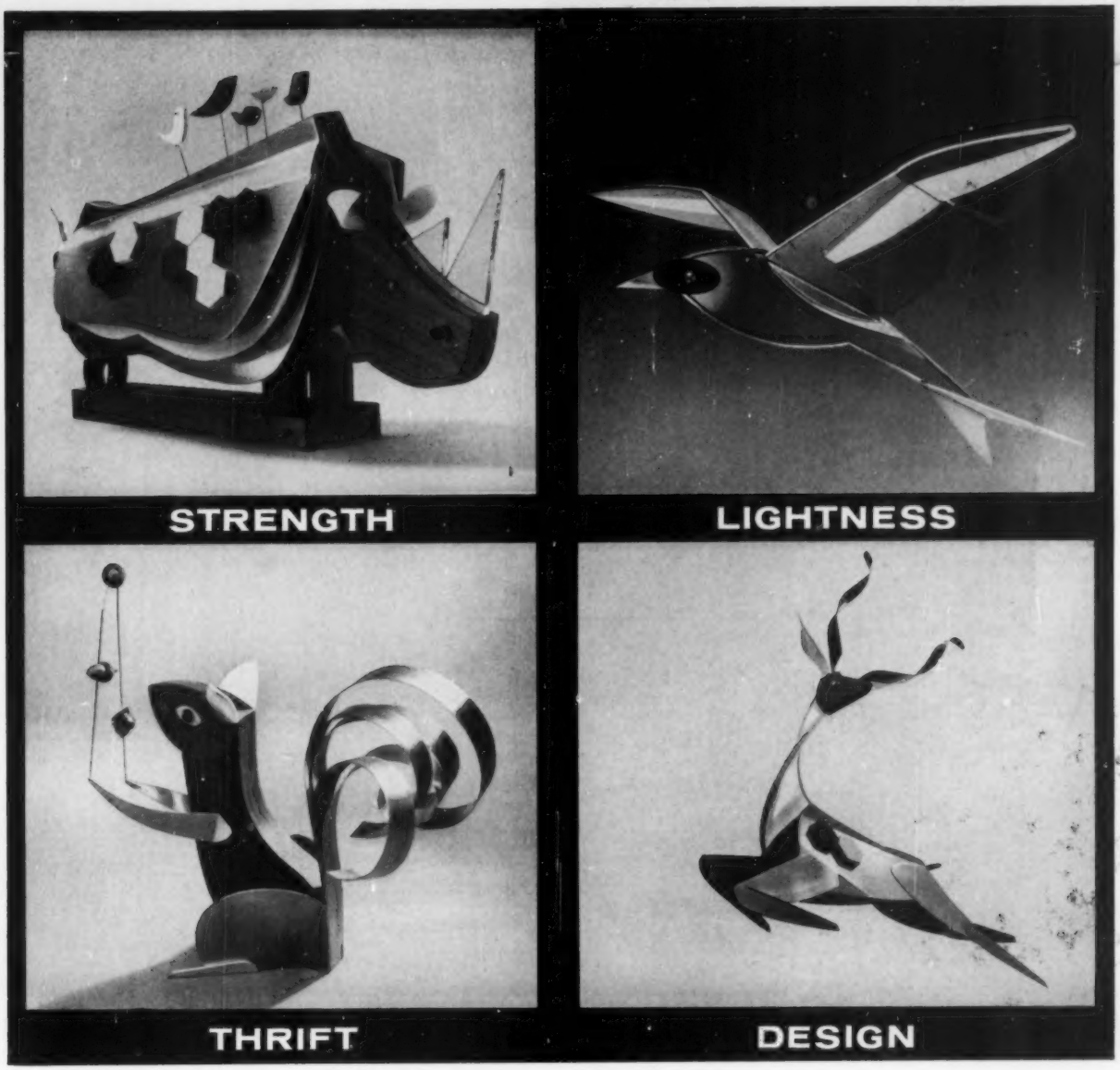

...get them all with 3M Adhesives!

The formulated talents of 3M Brand Adhesives can emphasize any one of a variety of fastening properties, depending upon which is crucial for the particular job at hand. But all offer the following advantages . . .

STRENGTH for example. SCOTCH-WELD® Brand Structural Adhesives create bonds that often are stronger than the materials joined! They distribute stress loads uniformly, with flexibility that resists vibrational fatigue. Fastening holes are eliminated, material integrity is preserved, joints are sealed against corrosion.

LIGHTNESS adds appeal! 3M Adhesives increase product appeal, save freight and handling costs, help take pounds off today's metalworking products. They eliminate mechanical fasteners, increase the strength of a lightweight assembly by distributing stresses evenly over a wide area.

THRIFT is a bonus. Many operations are eliminated, e.g., hole-making, countersinking, heat treating. No bolting, riveting, stapling, welding, brazing, sealing to do!

DESIGN freedom: Parts are fewer, assemblies simpler, unions stronger, using 3M Adhesives. You have a wider choice of materials, because 3M Adhesives bond practically any kinds of materials to themselves or other materials, e.g. aluminum, brass, ceramics, copper, glass, magnesium, permanent magnets, plastics, steel, stainless steel, wood.

What sticky problem of design, production, or sales can these modern adhesives help you solve? Why not call in your nearest 3M Field Engineer for consultation? Or write: AC&S Division, 3M Company, Dept. SBS-71, St. Paul 6, Minn.

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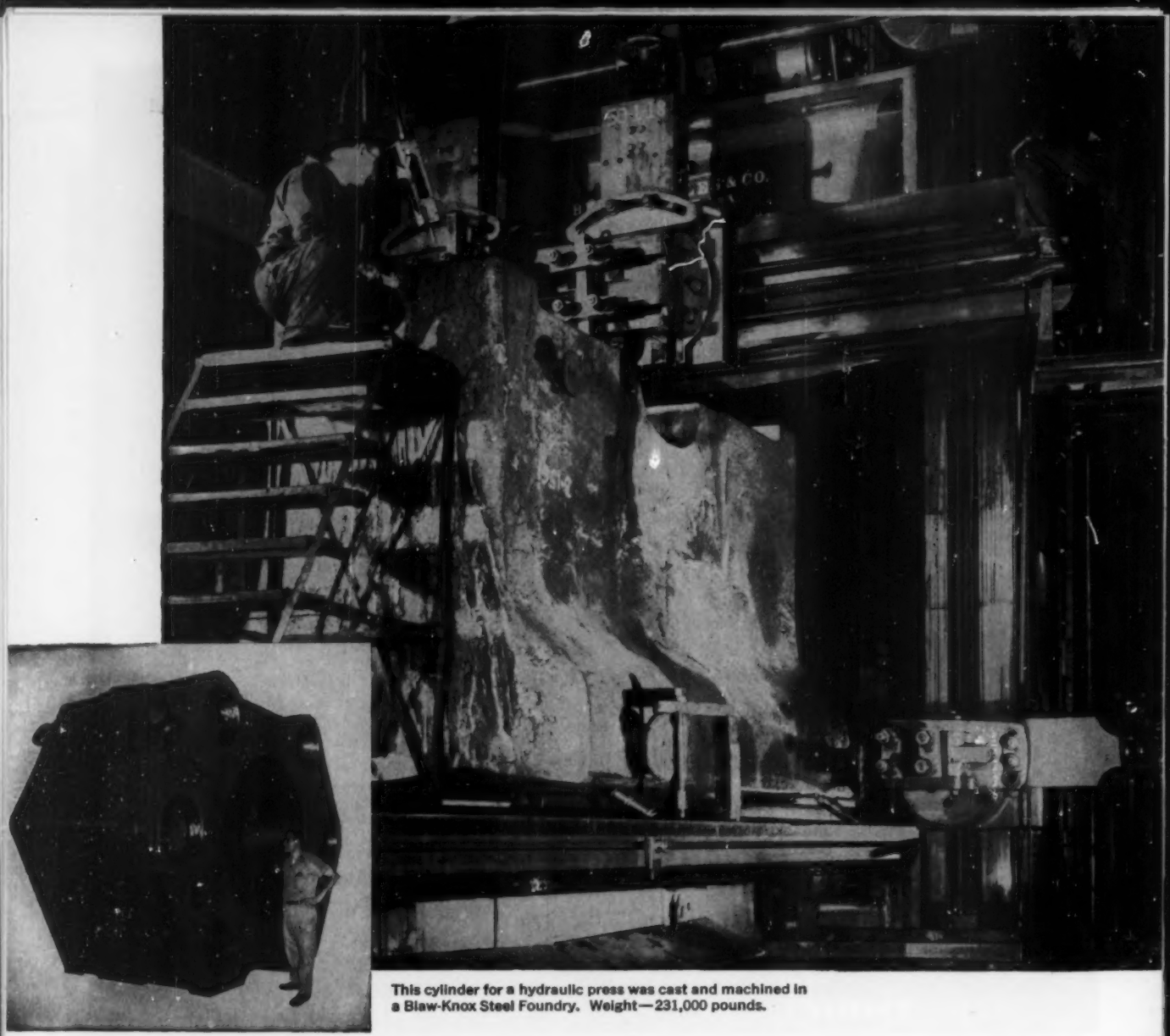
ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW



This cylinder for a hydraulic press was cast and machined in a Blaw-Knox Steel Foundry. Weight—231,000 pounds.

Blaw-Knox Steel Foundries have machine capacity to handle the most unusual product requirements

Planing, turning, milling, or boring the most unusually dimensioned casting is no problem in a Blaw-Knox Steel Foundry. There you will find planers up to 15 feet × 15 feet × 36 feet, lathes with an 84 inch swing, and planer type milling machines up to 6 feet × 6 feet × 25 feet. In the same machine shops, you will find the smallest precision tool room equipment.

This huge line-up of tools is part of the basic equipment of each of the five Blaw-Knox Steel Foundries. Because Blaw-Knox is one of the world's leading builders of rolling mills and industrial machinery, its machine shops are equipped to handle all of the operations necessary to finish a steel casting for assembly into the complete unit or sub-assembly.

Machining to exact specifications with a wide variety of tools is another way Blaw-Knox Steel Casting Service adds value to your product. There is no need to ship the rough casting to another location for machining. You have the advantage of a single responsibility from patternmaking to shipping.

If you design or build a product using cast steel components, ranging from 50 pounds to 300,000 pounds, Blaw-Knox would like you to have a copy of our brochure detailing Blaw-Knox Steel Casting Service. Write to the Foundry and Mill Machinery Division, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.

BLAW-KNOX

Steel Castings

PRODUCT ENGINEERING HORIZONS

July 17, 1961

That Cultural Fence

We have a carefully maintained fence between the two cultures—liberal arts on one side, science and technology on the other. It's a domestic armaments race, with each side fearful that the other will prevail, each side building "defenses," each side blaming our difficulties on the other.

To maintain the fence, the sides have created mutually exclusive definitions. But what is the opinion of the man on the fence? C. P. Snow has expressed his ideas (PE—Mar 6, '61, p 56). Now Dr Glenn T Seaborg, AEC chairman and another fence sitter (in this instance not a derogatory appellation) has expressed his. He defines the liberally educated person as "one who is aware of the nature of his physical and social environment and of his own nature. He understands the origins of the world's social, religious, governmental and political institutions and the ideas upon which they are based. He is a person who, because of this knowledge, has some basis for making intelligent decisions to adjust to his environment or to change to a better one."

Simple, and with no elements impossible for either side to achieve. Then the fence disappears. Dr Seaborg speeds the process by pointing out: "It is important today that a liberally educated man be as well acquainted with science—its method and spirit, its cultural and aesthetic aspects—as he should be with the great classics. Therefore, the graduate in the non-scientific disciplines should have a sound training in mathematics. He should be conversant with the basic principles and major developments in the physical and the life sciences. In sum, he should be as literate in science as he is in other fields of knowledge.

"But is he? I fear that he is not because we have waited too long in this exciting age of science to increase the quality and scope of science teaching in liberal-arts education. We have not faced up to the new needs. . ."

Here is the need—to destroy the fence by mutual understanding, just as so many fences have disappeared in middle-income housing areas. Each resident respects his neighbor's rights—and the need for the fence, based on fear, is gone. Then the two cultures become one, each point of view understood by the other, each contributing its share to meeting the needs of the world of change that is all about us.

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NEW

CAGEROL®

CAGE TYPE
HEAVY DUTY
NEEDLE ROLLER
BEARING

BY McGILL®

INCREASE EXPECTED LIFE UP TO 10 TIMES!

You need CAGEROL bearing performance if higher speeds and increased misalignment have prevented the utilization of needle bearing load capacity in your applications. Most important, CAGEROL bearings can deliver up to 10 times more expected life where misalignment and increased speeds exceed the capabilities of ordinary and guided needle bearings. The difference is in the exclusive McGill construction that features tapered retainer pockets for balanced roller guidance, crowned rollers, and black oxide retainer finish. CAGEROL bearings are interchangeable with all heavy duty needle roller bearings — with or without inners in two bore sizes.

McGILL MANUFACTURING CO., INC., Bearing Division
201 N. Lafayette Street, Valparaiso, Indiana

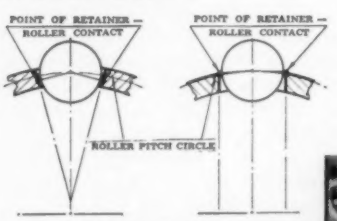
1 Exclusive crowned roller construction, electronically gauged to insure precision contour and size uniformity. Relieved ends assure even load distribution.

2 Flat ends fully engage integral race shoulders, provide maximum support.

3 Proper guidance assured by tapered retainer pockets. The design insures *balanced* roller support and eliminates corner wear from edge loading of straight pockets where retainer OD and pitch circle are coincident.

4 Simultaneously punched pockets assure accuracy of race and roller alignment. The black ferrous oxide retainer finish absorbs and retains lubrication, reducing the friction coefficient.

5 SAE 52100 steel outer race has optimum hardness and surface finish.



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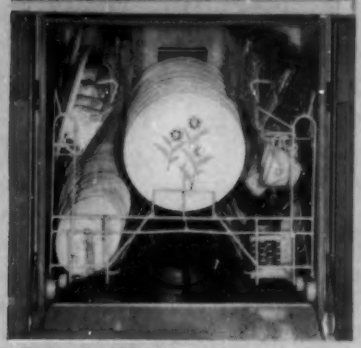


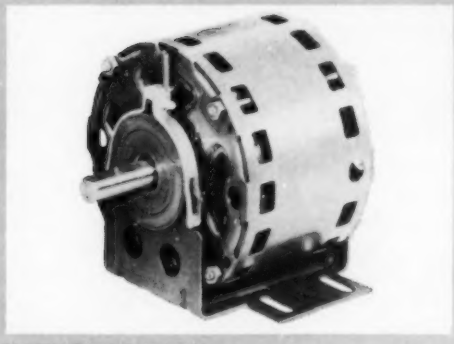
VINYL PLASTISOL

ALKYD PAINT

ALUMINUM SPRAY

a fresh look at

Functional Finishes for Metals



INSULATING VARNISH

CHROME. TIN PLATE

Herbert L Kee, *assistant editor*

How do they compare in properties? When do you need them? How do you apply them? How do you specify them? How do costs compare?

■ A part usually must withstand more abuse at its surface than internally. This is why the surface is important for more than decorative reasons. It explains why one of the most economical design approaches is to make the part from one base material and then do something to its surface—either alter it in some advantageous way or provide it with a functional coating of some other material.

continued, next page

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Such finishes provide the designer with several functions he may need. Among these are:

1. Corrosion resistance
2. Wear resistance
3. Heat- and oxidation-resistance
4. Electrical and magnetic properties
5. Soldering aid
6. Lubrication
7. Reflectivity

CORROSION-RESISTANT FINISHES

Most functional finishes are for protection against corrosion. These include organic and inorganic paints, electroplated materials, hot-dipped coatings, thick vacuum-deposited coatings and conversion coatings.

Organic paints

In this class are the most widely used corrosion finishes. They provide a broad choice of decorative colors, are cheap, will cover any size part made of any metal, are easy to apply by a number of methods, and are easy to repair.

The statistics on this method show that it will usually, but not always, cost more than simply letting the metal corrode away. A typical chart (below) plotted for steel, shows how to judge quickly whether painting will pay. The extra-cost penalty becomes higher if paint is put on a more corrosion-resistant metal. For example, high-strength steels like Cor-ten resist corrosion about four times better than carbon steel. So the cost of painting must be justifiable—by these four potential benefits:

- better appearance
- lower initial cost
- better mechanical performance
- better structural performance

Appearance is the main reason for painting. Painted metal products in indoor service are usually repainted before the film deteriorates sufficiently to permit metal corrosion. These decorative requirements not considered functional include gloss, gloss retention, resistance to yellowing and staining, resistance to fading. Color is functional when it serves to distinguish among parts.

Initial cost can be lowered by painting—through savings in metal thickness needed for a long 10- or 20-year corrosion life. Further, corrosion is not uniform—it is highest at such critical areas as overlaps in riveted or spot-welded joints. Excessive corrosion in these areas is difficult to detect.

More efficient structures result from reduced weight and smaller dead loads.

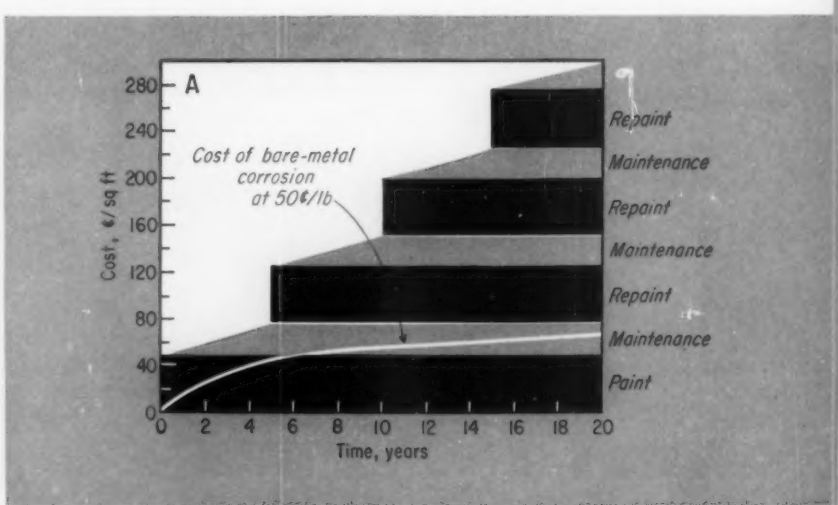
Mechanical performance is maintained by painting because it prevents contamination by corrosion products of lubricants or between mating parts.

The paints are a complex mixture of resins, plasticizers, driers, pigments, hardeners, modifiers and solvents. Each ingredient contributes to the chemical and physical properties of the paint film and any variation in formulation will generally alter the final properties. Although there are good formulations for specific applications, no one formulation is good for all applications.

Also, the composition of paints is proprietary and even within a given classification, performance will vary from one paint to another, depending on minor differences in formulation.

When you have comparison test data for a number of paints over the entire range of service conditions, it is simple to select the formulation. You can use Table I (p. 42) to check your choice, or to narrow the number of candidates for testing. Almost any paint will adhere to any metal to provide color for a decorative coat. For corrosion resistance, however, the alkaline-forming metals such as magnesium require alkaline-resistant primers and top coats to prevent undercutting where metal is exposed by scratches.

Without test data, it is easier to decide what your requirements are and bring them to one of the larger paint companies who formulate paints in a variety of basic resins. These companies will recommend a formulation to meet your specific environment. They may also point out conditions you overlooked. In one example, a refrigerator manufacturer who distributed in northeastern and midwestern states used an indoor finish. When his distribu-



COMPARISON OF PAINTING COSTS over the entire lifetime of a steel structure shows in all three cases that painting costs more than allowing the steel to corrode. But costs are less when the coating is kept up with maintenance and repainting every 2 years (C) because the coating does not deteriorate sufficiently to require extensive surface preparation and priming.

tion spread to southern states, the paint company recommended a change to an outdoor paint because in the South, refrigerators are often kept on back porches.

Preparing the surface properly can extend life of the paint film by two to three times. Surface treatments are divided into two categories: Sand or grit blasting for parts too large to dip in a tank, or for field-painted structures; degreasing followed by a conversion treatment for parts that can be immersed in a tank.

- The chromate conversion films promote paint adhesion both chemically and mechanically. They are good paint bases and are corrosion resistant, especially when supplemented by chromate primers.
- Phosphate treatments are cheaper but less inhibitive to corrosion. These porous films promote adhesion almost entirely by mechanical action. On magnesium, phosphate films are soluble and are recommended only for mild interior service. Also, magnesium parts cannot be treated in the same bath used for other metals because heavy-metal salts such as iron form cathodic materials that accelerate corrosion.
- Paint primers serve as carrier for inhibitive pigment and promote adhesion of subsequent topcoats. Relative importance of these varies with the particular metal. Where it is impossible to remove all the rust from steel, the oil base or oleoresinous paints are used for their ability to wet and adhere. For magnesium, primers should be chosen for alkali resistance of the vehicle because pigments in primers are only partly effective in protecting this metal.
- Inhibitive pigments are red lead, iron oxide, carbon black, and chromate pigments such as strontium chromate, basic zinc chromate, zinc tetraoxychromate. For the light metals, the chromates are preferred because iron oxide and red lead contain cathodic or potentially cathodic materials that will accelerate corrosion. For immersion in fresh water, titanium dioxide is preferred over the chromates—it is insoluble and therefore prevents blistering.

Specifying the paint coating depends on where the painting is done—in your own plant, or subcontracted or purchased on finished parts.

When painting is done within the plant and adequate service data is available, specify the paint composition and the application process.

Where painting is subcontracted, a requirement type of specification is preferred. It gives more latitude in composition of the paint and the way it is applied—but specify tests that painted part must pass. A typical specification of this type requires the part or sample to:

(a) withstand immersion in a specified soap or detergent solution for a certain time
(b) withstand immersion in gasoline or oil for a specified time
(c) withstand flexibility, impact and abrasion tests
(d) prevent corrosion of specific metals during a specific number of hours of exposure to salt spray
(e) dry to a certain hardness after baking
(f) match a specified color or gloss.

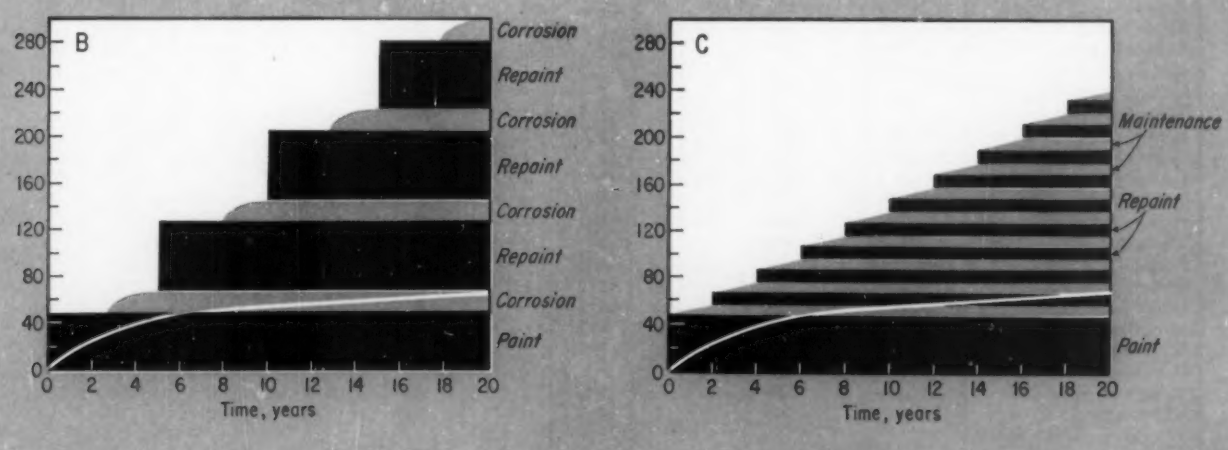
These specifications should not be confused with performance specs such as used in the building industry. These might specify that the product be painted with a certain color and that the paint last for 10 years. This type of performance specification is not practical because the only real test of the paint life is to wait 10 years. By that time the contractor or paint supplier may no longer be in business.

Cost of organic paint films can be estimated when you know the cost per gallon of paint and the percent solid content. Roughly, 1 gallon of paint with 100% solids will cover 1600 sq ft with a 1-mil (0.001 in.) film after drying. A gallon of paint with 50% solids will give 800 mil-sq ft. If a 2-mil coating is required, the paint will cover 400 sq ft.

Other organic finishes

Special organic finishes are used for properties which the ordinary paint films cannot provide.

- Chlorinated rubber coatings furnish good resistance to salt water. They are also resistant to alkalis and weak acids.
- Silicon resins are heat resistant. They are expen-



sive but perform well up to about 800 F. They require a sand blast down to base metal. Conversion pretreatments are not recommended.

• Thick bituminous coatings made from coal tar or asphalt have good resistance to moisture penetration and attack by soil organisms. They are used to protect buried metal parts.

• Thick coatings of polyethylene, vinyl, rubber or nylon are scuff and cut resistant, and can absorb mechanical impact. They are used for corrosion resistance in dishwashing racks, plating equipment and other handling equipment where mechanical contact cannot be avoided.

• Urethane or isocyanate coatings are abrasion resistant. Although expensive, they are useful for linings, coatings for seals that rub against moving parts, and other wear applications.

Inorganic finishes

Inorganic paints such as zinc silicate are a cross between galvanizing and a ceramic. They have resistance to abrasion, withstand weathering and are insoluble in organics. However, because they contain zinc they cannot withstand strong mineral acids or caustics. A good grit or sand blast surface is a must.

The zinc-inorganics are often used as a prime coat for high-quality organic finishes. The combination will perform better than either the zinc-inorganic or the organic coating by itself.

Galvanizing offers cheapest protection per square foot. Its galvanic action is most advantageous in outdoor coastal applications and, when coupled with paint films offers long corrosion-resistant life. This painting, however, requires aging the galvanized metal, or treating the surface with a conversion coating or precoating with a wash primer that contains a neutralizer such as phosphoric acid.

Aluminum hot-dipped coatings give at least four times the corrosion protection of galvanizing for the same coat thickness. They are three to four times more expensive but also offer protection at elevated temperatures and are easier to paint without special treatments or primers.

Hot-dipped lead coatings give best corrosion life for steel in industrial atmospheres. The coatings, cathodic to steel, must be thick and free of "holidays" pores or bare spots).

Hot-dipped tin is limited to food-handling equipment because of the high cost of tin, roughly $1 per lb. Tin is more often electroplated because coatings can be thinner. These films, however, are porous and must be sealed by remelting.

Sprayed metal coatings (metallizing) extend the metallic zinc and aluminum finishes to parts too large to be immersed in a molten bath. These coatings contain appre-

I—How the organic coatings compare as functional finishes (E = EXCELLENT; VG = VERY GOOD;

RESIN	COST			PHYSICAL PROPERTIES						
				Adhesion						
	Cost, ¢/sq ft/mil	Coverage, sq ft/gal./mil	Thickness, mil	Metals	Old Paints	Hardness, Sward Rocker (8th day)	Flexibility	Taber Abrasion Res., cycles	Max Temp., °F	Impact Res.
Alkyd	1.50	450	1.5	F	VG	24	E	3500	200	VG
Alkyd Amine	1.75	450	1.5	E	G	30	VG	5000	250	E
Alkyd-Urea	——	450	1.5	VG	G	28	VG	5000	225	E
Styrenated Alkyd	1.75	400	1.5	E	VG	28	G	5000	200	G
Alkyd Phenolic	——	450	1.5	E	G	34	G	5000	250	G
Alkyd Silicone	——	500	0.6	F	E	16	F	1000	1000	G
Acrylic	2.75	350	1.0	VG	P	24	E	2500	180	E
Bituminous	0.2–1.5	Low	30–250	E	—	—	E	——	300	E
Nitrocellulose	2.50	200	1.0	G	P	26	E	2500	180	E
Butyrate	2.75	200	1.0	G	P	26	E	2500	180	E
Epoxy (100%)	——	450	1.8	E	P	36	E	5000	400	G
Epoxy Amine	——	500	1.8	E	P	36	G	5000	400	G
Epoxy-Urea	2.00	500	1.8	E	P	34	VG	5000	400	G
Epoxy Melamine	——	500	1.8	E	P	36	VG	5000	400	G
Epoxy Phenolic	——	450	1.8	E	P	44	VG-E	5000	400	G
Epoxy Ester	1.75	450	1.5	VG	F	30	G	5000	300	E
Fluorocarbon (air-dried)	15.00	200	1.0	VG	P	20	G	1000	450	E
Phenolic	1.75	350	1.5	E	G	38	G	5000	350	G
Polyamide (nylon)	——	——	2–30	VG	—	—	G	——	300	VG
Chlorinated Rubber	1.50	450	1.5	VG	E	24	VG	5000	250	G
Neoprene	1.25	300–400	2–10	VG	—	10	E	5000	250	E
Hypalon	1.50	250–350	2–30	VG	—	—	E	5000	350	E
Silicone	6.00	350	1.0	F	E	16	F	2500	1200	G
Urethane	1.50	450	1–2	E	F	35–65	E	5000	300	E
Vinyl	2.50	250	1.0	VG	G	20	E	5000	200	E
Vinyl-Alkyd (approx. 1:1)	——	300	1.2	VG	G	26	VG	2500	200	VG

ciable amounts of oxide intermixed with the metal, are porous, and must be sealed for maximum corrosion protection.

Sprayed aluminum is usually reserved for hot, corrosive environments. When sealed with a silicone-base aluminum paint, it will protect steel to above 1000 F, wet or dry.

Electroplates are most used for their decorative appearance. For the same corrosion life, organic coatings are cheaper. Further, most electroplates are porous and must be sealed by remelting or mechanical buffing. The common chromium-nickel or chromium-nickel-copper combinations have sufficient surface hardness to resist wear environments such as scrubbing with steel wool and household cleaners. They are inert to most household chemicals and will resist staining. Although the protective copper and nickel coatings are cathodic, most applications do not receive the continual wetting that completes a galvanic cell and thereby accelerates corrosion. Even after initial rust spots show through the chome plate, tight adherence of the coatings still offers some corrosion protection. In indoor applications, the time for complete breakdown of these coatings is 10 to 20 times longer than the time at which the initial rust shows through.

Zinc and cadmium plates protect against corrosion because they are anodic to steel. Because the plated coatings are thin and offer little galvanic action, these platings are limited to nuts and bolts and other hardware too small to coat economically by hot-dipping. The plated cadmium is more expensive than the zinc but is generally preferred for electrical parts because it is more easily soldered.

Some of the corrosion-resistant coatings above also prevent stress-corrosion cracking in steels. Limited data obtained on stressed specimens in marine atmospheres, Table III, show that some coatings are more effective than others. These ratings however, cannot be used for other metals or atmospheres because each stress corrosion situation is different.

MECHANICAL FINISHES

These give a metal surface stronger and harder than supplied by the corrosion coatings. Valued for their resistance to abrasion and wear, the mechanical finishes are of two basic types:

- Those that strengthen or alter the top layer of base metal by diffusing an active ingredient into it. Under many conditions such processes put the surface layer into compression and add to fatigue strength. The converted surface, however, takes on some of the limitations of the base-metal properties.
- Those that bond-on an entirely new material. They can build up heavy thicknesses, can be chosen for wear

G = GOOD; F = FAIR; P = POOR)

RESISTANCE TO ENVIRONMENT AND CHEMICALS										EASE OF APPLICATION				
							Alkalis				Air-drying Time Needed for			
Weathering	Salt Spray	Alcohols	Gasoline	Hydrocarbons	Esters, Ketones	Chlorinated Solvents	Dil.	Conc.	Water	Need for Primer	Handling	Recoating	Full Hardness	Max Corr. Res.
E	E	F	G	G	P	P	G	G	F	Yes	4 hr	4 hr	12 hr	48 hr
E	VG	G	E	E	P	P	VG	G	G	No	—	—	—	—
E	G	G	E	E	P	P	G	G	F	No	—	—	—	—
G	G	G	E	E	P	P	G	VG	G	No	30 min	4 hr	4 hr	48 hr
E	E	G	E	E	F	F	F	P	E	No	60 min	6 hr	6 hr	48 hr
E	E	F	E	P	P	P	P	P	E	Yes	2 hr	4–6 hr	12 hr	12 hr
E	E	G	G	F	P	P	G	F	E	Yes	15 min	15 min	12 hr	24 hr
E	E	P	P	P	P	P	E	E	E	No	24 hr	—	24 hr	—
E	E	G	G	F	P	P	P	P	F	Yes	15 min	15 min	12 hr	24 hr
E	E	G	G	F	P	P	P	P	E	Yes	15 min	15 min	12 hr	24 hr
G	E	E	E	E	F	E	E	E	VG	No	2 hr	6–8 hr	12 hr	7–10 days
E	VG	E	E	E	VG	E	E	E	G	No	2 hr	6–8 hr	12 hr	7–10 days
G	VG	E	E	E	VG	E	E	E	G	No	—	—	—	—
E	VG	E	E	E	VG	E	E	E	G	No	—	—	—	—
E	VG	E	E	E	E	E	E	E	E	No	—	—	—	—
G	E	VG	E	VG	F	F	E	E	VG	Yes	2 hr	8 hr	8 hr	5 days
E	E	E	E	E	E	E	E	E	E	Yes	15 min	12 hr	12 hr	12 hr
E	E	E	E	E	E	G	P	P	E	No	30 min	30 min	4 hr	24 hr
P	F	G	G	—	—	—	G	G	F	No	—	—	—	—
E	E	F	G	P	P	P	VG	F	VG	Yes	2 hr	4–6 hr	4–6 hr	24 hr
E	E	E	F	P	P	P	E	E	E	No	30 min	4 hr	4 hr	7–10 days
E	E	E	P	F	P	P	E	E	E	Yes	30 min	4 hr	4 hr	7–10 days
E	E	P	VG	VG	P	P	P	P	E	Yes	2 hr	4–6 hr	12 hr	12 hr
E	E	F-G	F-G	F-E	F	P	VG	F	E	No	1–2 hr	3–4 hr	12 hr	5–7 days
E	E	E	E	G	P	P	E	E	E	Yes	30 min	4–6 hr	4–6 hr	24 hr
E	E	G	E	P	P	P	G	P	E	Yes	2 hr	4–6 hr	6–8 hr	6 hr

resistance and for such fringe benefits as corrosion resistance and high-temp strength. The processes usually lower fatigue strength and are more costly in quantity production because they require high labor cost per unit.

Strengthening treatments

Carburizing—This method adds strength by increasing carbon content of steel surfaces. Subsequent quench-hardening and tempering then transforms the surface into a hard layer. Although favored for wear resistance, the process also improves fatigue strength of parts subjected to repeated bending. With heavy case thicknesses, parts treated by carburizing have good resistance to indentation or brinelling. Carburized cases, however, lose their hardness above 500 F.

Base steels are chosen for ability to fulfill mechanical requirements in the core. The SAE 1000 and 1100 steels are cheapest but weakest. They are used for carburizing where the case is needed only for wear resistance. At the other extreme, the SAE 9300 steels are for heavy-duty critical parts. They harden deeply and uniformly because of their alloy content. Other steels, such as the SAE 8600 steels, with lower alloy content cost less and are popular because their final case hardness equals that of the 9300 steels.

Generally it is cheaper to carburize the entire surface because this saves cost of masking. But this is not always practical. For example, long hollow parts should not be carburized on the ID if they are to be straightened—because any cracks on the ID will go undetected. Solid shafts, on the other hand, are generally carburized all over and not straightened. Even if the parts will be straightened, cracks are detectable.

Hardness for wear surfaces should be Rockwell C55 to 63. Because hardness of steel depends mainly on carbon content, hardness of the case decreases with depth from the surface. A good rule of thumb is that RC 60 will extend to about 25 to 30% of the total case depth. Finish grinding should be kept to a minimum to maintain as much hard case as possible.

A nitrided case gives excellent resistance to wear, as in cylinder-barrel liners for internal combustion engines, rubbed by chrome-plated piston rings. Further, this hardness is maintained at elevated temperatures. For example, a nitrided case on Nitralloy is as hard at 750 F as at room temperature and can be heated to 1000 F without losing hardness when it cools.

Distortion or warpage is less than in carburizing because the case does not require subsequent hardening. Some dimensional growth occurs during nitriding but allowance for this can be made. Most low-alloy steels will form the hard nitrided surface, but special steels such as the Nitralloys must be used for best nitrided properties.

Carbonitriding gives better wear resistance than that of straight carburizing. The case is also more temperature-resistant, and because carbonitriding temperatures are lower, there is less distortion and cracking. The method is used for small, uniform, thin parts that do not distort excessively because the thin case does not allow substantial removal of stock.

In carbonitriding, adding nitrogen along with carbon increases hardenability and a less drastic cooling rate is needed to meet required hardness. Depending on the temperature, time and proportions of carburizing and nitriding gases, either carburizing or nitriding will predominate.

Cyaniding is the liquid-bath form of carbonitriding. Process times are short; hardening costs are low. The process is normally used for small uniform parts where the thin case (usually under 0.010 in.) is sufficient to impart wear resistance.

Selective hardening of local areas can be accomplished by selectively heating an area, then quenching it. In quenching, heated areas become hard and unheated sections remain at the initial or core hardness. This process takes the place of selectively carburizing a surface and then heat treating the entire part.

Hard anodic coatings on aluminum and its alloys give resistance to sliding wear, abrasion, erosion and corrosion. Scratch-hardness of the hard anodic coat on aluminum is similar to that of hard chrome plate. In wear resistance, the anodic coating is better than chrome plate or steel which has been cyanide-hardened. Although these coatings are also good thermal and electrical insulators, hard coatings tend to craze under temperature changes because of the extreme thickness. Thickness ranges up to 5 mils are about 20 times the top thickness for conventional anodic coatings.

Surface buildup from hard anodizing averages about 50% of the total coating thickness. Because this buildup of brittle coat crumbles at sharp corners, all edges should be broken to a minimum radius of 0.005 in.

Fatigue strength is lowered by thick anodic coatings. The decrease in life can go up to 65% with certain alloys —average is about 30%. For alloys 220 and 356, there is little effect on fatigue life. Coating thickness has no further effect on life—a 1-mil coating will exhibit the same

II—Metal-finishing costs

CLEANING TREATMENTS	Cost Range, cents/sq ft
Solvent cleaning	0.35–1.4
Alkaline cleaning	0.35–1.4
Acid pickling	0.70–2.1
Sand or grit blast	0.50–5.0
Polishing	2.8–14.0
CHEMICAL TREATMENTS	
Alodine Process	2.1–4.2
Bonderite 170 Process	2.1–4.2
Phosphate	1.4–2.8
Chromic acid pickling	2.6–4.5
Dichromate pickling	4.3–6.7
ELECTROLYTIC OXIDE FINISHES	
Sulfuric acid	14–35
Chromic acid	21–42
Hard anodize	40–60
COATINGS	
Organic coatings	2.0–5.0
Hot-dipped galvanize	4.9–9.0
Hot-dipped aluminize	10–40
Sprayed aluminum	5–10.0
Sprayed zinc	12.0–18.0

loss as a 5-mil coating. Tensile strength also decreases somewhat because the coatings are weaker than the parent metal—average yield strength of the coating is about 10,000 psi.

Surface treatments

Overlaying the metal surface improves surface strength and hardness, giving resistance to wear and sometimes to corrosion. Because overlay properties are independent of the parent part, they can be chosen for the application. The processes, however, do not add significantly to part strength.

Hard chrome plates for wear resistance are deposited directly on the base metal. Base metal must be hard enough to resist deflection or indenting from parts bearing on it to avoid cracking the brittle chrome plate. The thick chromium deposits, 0.0003 to 0.010 in., can be plated in dense pore-free coats for added corrosion protection or purposely made porous to aid in lubrication—such plates as Porous Khrome are easily wetted by lubricating oils.

Sprayed coatings of a metal generally have better wear resistance than the same metal in unsprayed form because each sprayed granule is surrounded by a hard oxide layer. The coatings, which are porous, usually absorb enough oil to provide lubrication where external lubrication is marginal or intermittent. On the other hand, the composite—base and coating—cannot take impact or highly localized loads. In general, ductility of the coatings is low.

Any material, including metal, wood, plastic or ceramic, can be the substrate for a spray coating. For some base metals an intermediate sprayed-metal layer is used to improve bond. Usually, surface roughening by blast and a slight preheat will suffice to give a good shrinkage bond on the OD of a part. On interior diameters the coatings shrink away from the base metal. Heavier coatings, because they have high shrinkage force, may require undercuts machined into the base metal or an initial spray with high-melting molybdenum—it bonds onto nearly all base metals except copper or copper alloys.

Two carbon steels are used as sprays for wear resistance. The 0.80% carbon steel has over-all hardness of RC 40 (actually microhardness of the particle is RC 67 but over-all readings take into account porosity of the coating). The second, an 0.25% carbon steel with a hardness of RC 25 (particle hardness of RC 45), can be readily machined to a fine finish by normal machining tools.

Another common coating metal is type 420 chromium stainless steel. It has a tensile strength of about 40,000 psi and an over-all hardness of RC 25 to 40 (particle hardness is approximately RC 52). Sprayed 420 steel is finished by grinding. When sealed with a phenolic resin, it also provides corrosion protection for the base metal.

Sprayed coatings of molybdenum have high resistance to certain types of sliding wear. One example is the molybdenum spray on aluminum cylinder barrels to provide a wear surface. Hardness is high, about RC 40 (particle hardness is about RC 55). But sprayed-on molybdenum lowers fatigue strength of some base metals.

Alloy powders, flame-sprayed and fused onto the base metal, give coatings that resist abrasion and have excellent hot-hardness up to 1400 F. Such coatings are nonporous when fused, so give good protection against oxidation and corrosion. The coating metals, essentially nickel-chromium or cobalt-chromium alloys with fluxing agents, are applied in thicknesses from 0.010 to 0.125 in. Coatings are uniform and smooth, so require little grinding to bring them to finished size.

High-temperature flame-spraying processes and the newer

III—What coatings do for stress corrosion

Finish	Time to Failure (days exposure at Kure Beach)	
	On 12 MoV steel	On die steel
None	0.7	1.5 to 3
Preventive Against Stress Corrosion		
Aluminum applied after austenitizing	>420	>420
For Delaying Stress Corrosion		
Ni-Cd electroplate	>420	263
Zinc-dust dibutyl titanate	>420	395
Aluminum applied before austenitizing	4 to 66	46
Al-pigmented silicone applied after austenitizing	7	147
Aircraft-type zinc chromate primer	2 to 17	—
Electroplated Ni	405	0.7
Without Appreciable Effect on Stress Corrosion		
Electroless Ni	0.7	0.7 to 1
Electroplated Cr	0.7	0.01 to 4
Al-pigmented silicone applied before austenitizing	0.7	2 to 3
Silicone	0.7	0.7 to 5
Zinc chromate—iron oxide—alkyd paint	0.7 to 3	0.7 to 13
Zinc chromate primer	0.7 to 1	—
Rust-preventive wax	0.7 to 13	0.7 to 4
Rust-preventive grease	0.7 to 3	0.7 to 5
Strontium chromate—aluminum paint	0.7 to 1	—

plasma torch process can also deposit high-melting materials such as tungsten carbide, titanium carbide, chromium carbide. These carbide materials are hard, very wear-resistant and, when applied in thin coatings, can solve many special wear problems.

Hardfacing by welding or brazing is an inexpensive way to build up heavy wear layers that must resist impact shock loads. Thicknesses from $\frac{1}{32}$ to $\frac{1}{8}$ in. are heavier than those that can be economically deposited by any other method. Although initial costs are low—requiring little capital expense—costs for labor and materials are high. Because the hard overlays are usually tough to machine, much hardfacing is done on crude wear surfaces where the part need not meet finished dimensions. However, finished surfaces can be ground to dimensions.

A good starting point in selecting overlay material is the martensitic irons. These have good resistance to abrasion and light-impact load. They retain hardness up to 1000 F, have high compressive strength, and are easily applied by arc- or gas-welding. If impact or tensile stresses are moderate to high, tougher martensitic steels with less carbon are a better choice. Austenitic steels will resist impact better, and the nickel-base alloys and stainless steels have better corrosion resistance.

SINGLE SOLVENT SYSTEM DEGREASES, PHOSPHATIZES AND PAINTS. This system developed by DuPont (based on trichlorethylene, a nonflammable solvent) reduces painting costs by at least 20% because it needs no water rinsing or drying steps between processing stages. Further savings may be gained by recovering solvent vapors.

Above 1200 F, conditions favor choosing the cobalt-base alloys. They have good resistance to oxidation and corrosion from hot gases, and retain hardness and strength at elevated temperatures. These, however, are expensive, so are generally limited to elevated-temperature service. Other hardfacing materials contain hard granules of tungsten carbide for special tool and wear applications.

FINISHES THAT RESIST HEAT, OXIDATION

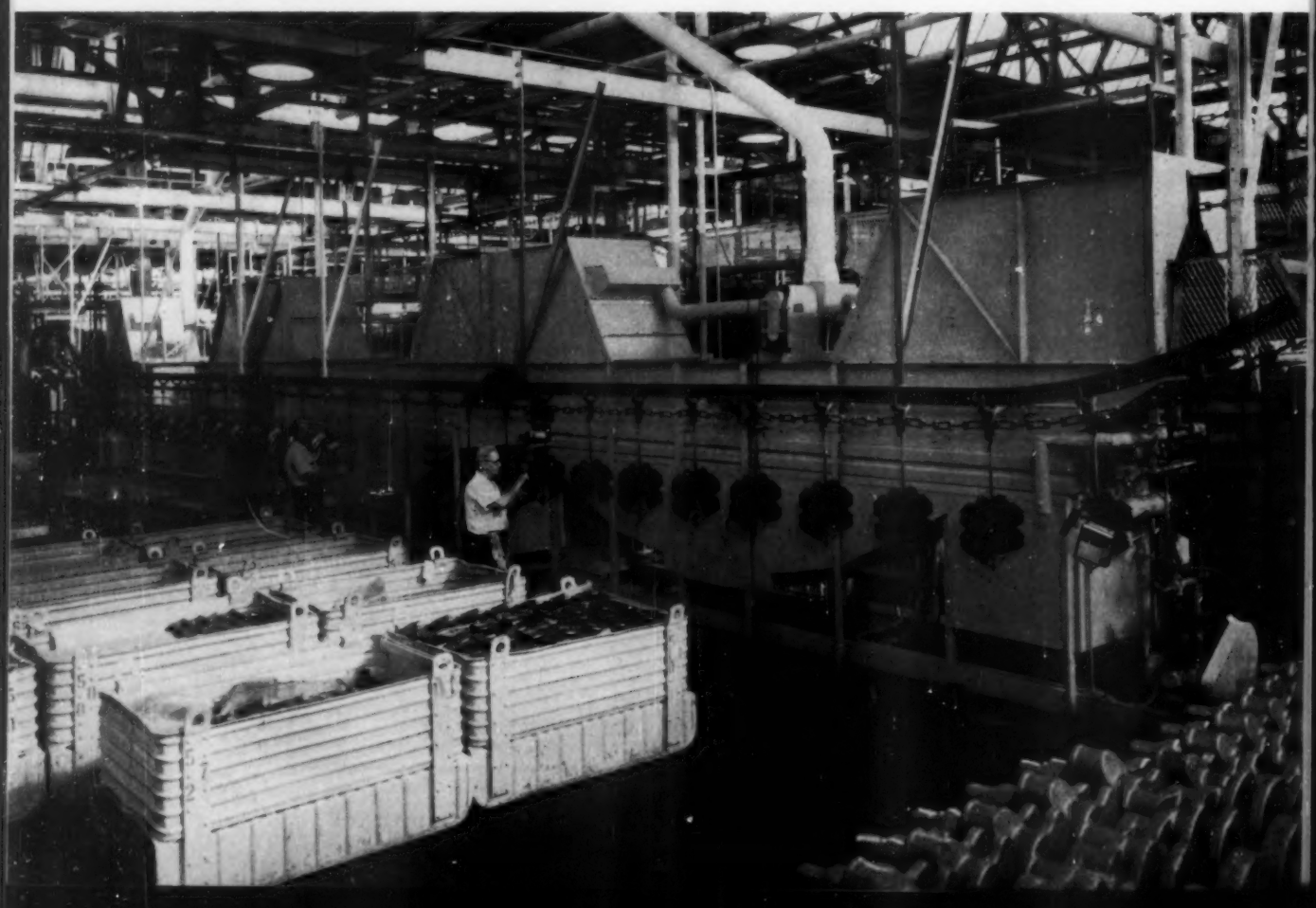
For temperatures above 1000 F, most metals must be protected from their environment. Ideally, the coatings should control oxidation and corrosion of the base metal, prevent erosion, and be compatible with the base metal.

Finishes that successfully resist oxidation above 1000 F are protective because they form adherent oxide scales or are inert to high-temperature oxidizing atmospheres.

Porcelain enamels, fired ceramic and vitreous ceramic coatings, will protect metals against oxidation and scaling. Their high hardness gives resistance to erosive wear from impinging particles, and they are inert to oxidizing or other corrosive gases.

Disadvantage is the expansion mismatch between ceramics and metals. These coatings are also brittle and will crack under high stress or impact. The crack can then cause failure of the base metal by oxidation through the opening or may grow into the base metal and cause brittle fracture or a fatigue failure.

Spray techniques can deposit ceramic coatings without heating the base metals appreciably. Although gas temperatures in a plasma torch exceed 30,000 F, temperature of



the substrate can be readily kept below 400 F. The high temperatures that can be reached allow coating with many of the new high-melting ceramics or intermetallics that cannot be furnace-fired onto a metal.

Aluminum coatings are among the cheapest finishes for temperature resistance.

1. Aluminum paints—silicones with aluminum pigment will protect metals from heat and corrosion up to 1000 F. Protection to somewhat higher temperatures is given by the leafing-type vehicles which deposit aluminum pigments in layers. On heating, the vehicle or binder vaporizes, leaving the aluminum which fuses into a continuous coat. These metal films, however, lose some of the resistance to wet corrosion when the parts cool.

2. Sprayed-coatings of aluminum on steel give heat resistance to 1500 F and beyond. The coatings are porous but can be sealed with aluminum-pigmented organics to decrease permeability to oxidizing gases. The bond is mechanical, so a rough surface is required for adhesion.

3. Hot-dipped aluminum coatings are continuous aluminum films bonded metallurgically by an intermetallic coating. Heat resistance is good—but above 1000 F the metallic aluminum overlay gradually diffuses into the metal, decreasing its corrosion resistance.

4. Aluminum prediffused into the metal, such as in Calorized coatings, are mainly a mixture of heat-resistant iron-aluminum compounds. Fatique strength of the base metal is substantially lower and the coatings are brittle. Low aluminum content does not prevent rusting but corrosion resistance is better than ordinary steels.

Chromium finishes are rivals of aluminum. Non-porous chromium plated on steel forms a highly adherent scale and is protective to over 2000 F, where metals lose most of their mechanical properties. The plating is relatively ductile and can protect the base metal during alternating heating and cooling. However, after prolonged heating, it will form a brittle alloy with iron and the resistance to thermal fatigue will go down. Sometimes, for better compatibility with steels, nickel is plated as a barrier to prevent formation of the alloy.

Diffusing the coating of chromium into mild steel such as in Chromizing and Alphatizing, is cheaper than making the part of chromium stainless steels. The diffused-coated parts are more corrision resistant because the Cr content concentrated at the surface is as high as 40% while chromium content of most chromium stainless steels is 12 to 18%. On the nickel-base superalloys the added chromium content improves oxidation resistance even more.

Ablative coatings provide short-time protection against extremely high temperatures. They usually contain organic resins that sublime or carbonize to form an insulating coating. These coatings, however, are limited to special applications like firewalls and missile nosecones where life of the part is sacrificed for minimum rise in temperature of components housed within.

ELECTRICAL FINISHES

Coatings for electrical purposes are used for their insulating and dielectric properties, conductive properties or magnetic properties.

Electrical insulations are chosen for their basic electrical

IV—Strengthening treatments for various service requirements

Type of Duty	Material and Treatment	Case Depth, in.
Very heavy		
Impact loads	Low-carbon alloy steel—carburized	0.060 or more
High bearing loads	Medium- to high-carbon steel—induction- or flame-hardened	
High-speed sliding	Hardfaced	
Heavy		
Sliding, rolling or abrasive wear	Low-carbon alloy steel—carburized	0.040
Indenting loads	Medium- to high-carbon alloy steel—induction-hardened	to
Alternate bending stresses	Hardfaced	0.060
Medium		
Moderate loads and wear	Low-carbon alloy steel—carburized	0.020
	Medium- to high-carbon steel—induction-hardened	to
Grinding permitted on finish surface	Metal-sprayed	0.040
Medium to light		
Moderate to light wear	Special 0.40% C alloy steel—nitrided	0.010 to 0.025
	Medium-carbon alloy steel—cyanide-treated	0.003 to 0.010
	Medium- to high-carbon steel—induction-hardened	0.010 to 0.020
Some stock removal after treatment	Metal-sprayed	0.010 to 0.020
Light		
Thin parts	Low-carbon steel—cyanide-treated	0.001 to 0.010
Light sliding wear	0.40% C alloy steel—nitrided	0.005 to 0.010
Little stock removal permitted	Hard chrome plate	0.003 to 0.010
	Hard anodize	0.001 to 0.005

properties. The accompanying thermal, mechanical and chemical properties help ensure that the insulation will retain its electrical properties during manufacture.

A comprehensive survey of all organic and inorganic materials for electrical purposes is compared in PRODUCT ENGINEERING's article "How to Choose the Right Electrical Insulation" (see Editor's Note). It compares the materials in detail for their electrical and dielectric properties, thermal endurance, chemical resistance and ability to withstand mechanical abuse.

Conductive coatings are generally conductive paints or thin metal films deposited by electroplating or vacuum coating. The conductive paints (which usually contain silver-powder pigment) are easily applied to local areas to form current-carrying paths. Current capacity is increased by painting on additional coats.

Thin conductive films are coated to provide uniform current density across the entire surface of a part. Some requirements for these films are: close control of thickness, adhesion to insulating materials like plastics or glass, and soldering ability. These coatings generally have little strength and are too thin to resist mechanical wear.

Magnetic films used mainly in magnetic recording devices, should have high coercive force and minimum bulk in order to store a maximum amount of magnetic information in a given space. While the magnetic oxide (ferrite) coatings are inexpensive and easily applied, the newer cobalt-nickel electroplates retain magnetism better and take up less space.

SOLDERABLE FINISHES

These are coated onto the less easily soldered metals to speed manufacturing and ensure reliability of the joint. Besides ease of soldering, other requirements for these coatings are retention of soldering properties after storage, and protection of the joint and base metal from subsequent corrosion.

The better electroplates for this purpose are rated for their soldering properties in Table V. Hot-dipped tin coatings are also excellent for soldering; however, these are limited to wire coatings or assemblies that can withstand immersion in the molten metal bath.

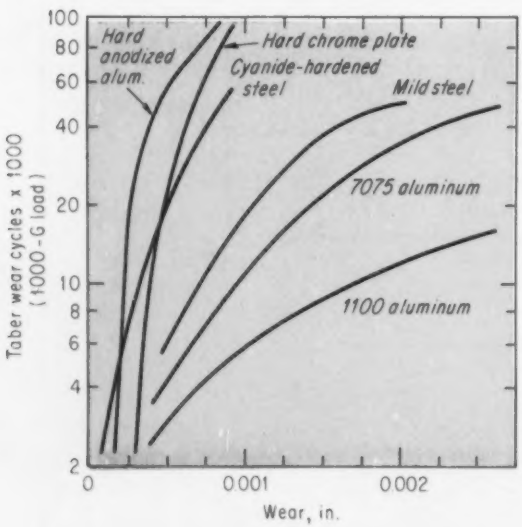
LUBRICATING FILMS

Solid-film lubricants bonded to the metal are better able to compete with liquid lubricants when loads are extremely high, speeds are low and surface temperatures are high. They also stand out in dirty environments that are abrasive, and are used particularly in sealed assemblies where mating surfaces are inaccessible.

The cured coatings have three limitations. The coatings are non-renewable, they do not cool as liquid lubricants do, and precoating treatments must be closely controlled for best service life.

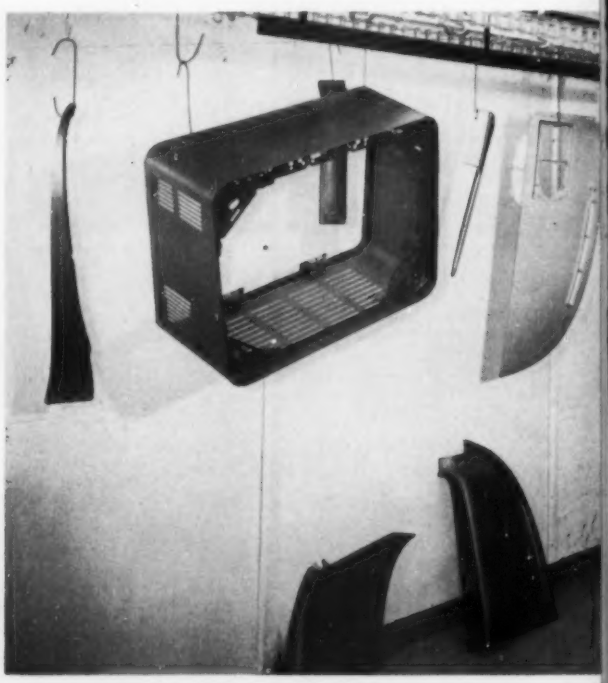
Today's coatings use as lubricating agents molybdenum disulfide (MoS_2) or graphite or both. As high-temperature lubricants, silver, boron nitride and silver iodide show some promise but are not commercially available.

Teflon enameled surfaces need no lubricants. They have a friction coefficient so low that oiling usually increases the friction. Teflon finishes are resilient and can absorb



ACCELERATED WEAR TEST compares finishes on aluminum and steel. These results from a rotating-wheel testing machine are helpful where coatings must withstand relatively light bearing loads.

SPRAYING THICK VINYL FILMS (below) on parts costs less than precoated vinyl-metal laminates. By coating after forming, spray method leaves no uncoated edges and requires less handling care during manufacture. Coatings of vinyl organosol dispersions can build up to 15 mils in a single coat.



V—Electroplates for soldering coatings

Coating	Min thickness for soldering, in.	Solderability to tin-lead solders	Storage life
Tin-cadmium	0.0001	fair	good
Tin-lead	0.0002	excellent	excellent
Tin-nickel	0.0005	excellent	excellent
Tin-zinc	0.000,15	excellent	excellent
Cadmium	0.000,15	good	fair
Copper	0.0001	fair	fair
Gold	0.000,08	excellent	excellent
Silver	0.000,05	excellent after plating	poor
Tin	0.000,15	excellent	excellent

VI—Coatings for thermal control

Surface	α/ϵ
REFLECTORS	
Metal smokes	18.0
Gold	6.0
Polished silver	3.0
Aluminum silicone paint	1.2
Aluminum paint (leafing vehicle)	1.1
Silicone paint (black)	1.1
Acrylic paint (black)	1.1
Epoxy paint (black)	1.0
Refractory oxides	1.0
Deposited ceramic coatings	0.9
Silicone paint (white)	0.33
Epoxy paint (white)	0.28
Titanium dioxide	0.20
Metallized mirror	0.15
ABSORBERS	

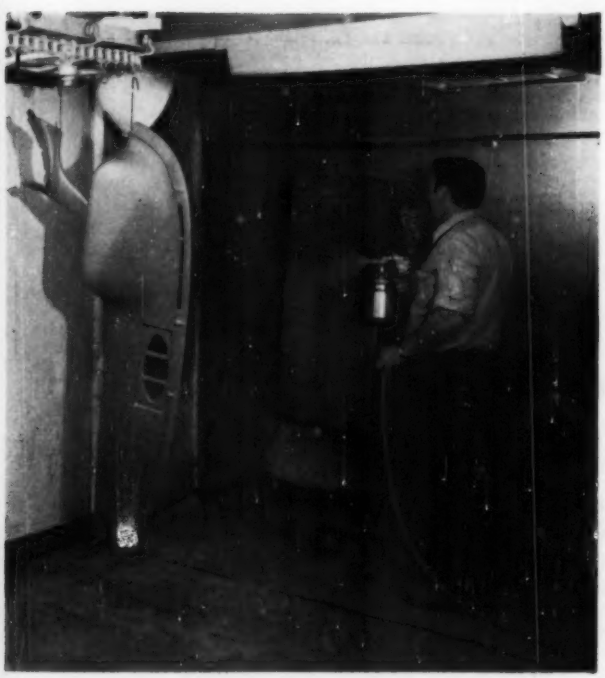
impact energy that sometimes causes fretting of surfaces in metal-to-metal contact.

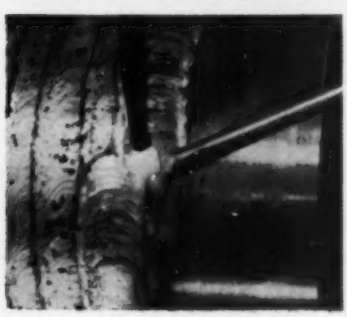
Two lubricating coatings not normally applied for this purpose are phosphate coatings and thick anodic films on aluminum. The first is a process aid in deep-drawing sheet-metals. It lubricates die surfaces, so less power is required for the drawing operation, and it reduces scratching of the metal surfaces. Thick anodic films, such as those formed in hard-anodizing, are normally not sealed for best wear resistance. The porous aluminum oxide film impregnated with oil makes an excellent self-lubricating bearing surface.

COATINGS FOR THERMAL RADIATION

Coatings for controlled radiation are selected both for their surface absorptance and emittance—rating their emittance is not enough. Although for most applications below 800 F, absorptance is almost equal to emittance, a more useful way of comparing coatings is the ratio α/ϵ, where α is the absorptance and ϵ the emissivity for particular wavelength or spectrum of the expected radiation (Table VI).

Painted finishes have a wide range of emissivities. They also give corrosion protection, are simple to apply and





TWO WAYS TO HARDCOAT FOR RESISTANCE TO ABRASION AND WEAR

1..Spray it on. This metal roll is being flamed-sprayed with 410 stainless steel. The coating particles harden as they cool on the base metal and require no heat treatment. Substrate material remains relatively cool—below 400 F.

2..Weld it on. Oxyacetylene flame welds hardfacing alloy (Haynes Stellite No. 12) on 304 stainless sleeve. The bearing here also must stand thermal shock. Base metal is preheated to 1000 F before welding.

repair. Emissivity is lower than with metal coatings (even with metal pigments) because the resins themselves have lower emission properties.

Metal films that are electrodeposited or vacuum-deposited are excellent low-emissivity finishes. The plated films have good abrasion resistance and are thick enough to offer some corrision protection; the vacuum-deposited films are too thin to protect against abrasion and corrosion. The deposited metals include nickel, gold, chromium, cadmium and rhodium.

Thickness of the coatings is important. If the coating is thin, the base metal will affect over-all emissivity. Oxidation will increase emissivity of metals, and aging generally lowers the emissivity of organic finishes.

ACKNOWLEDGMENTS

Many companies assisted materially in the preparation of this report and in checking the manuscript. Among these were: Allied Research Products Inc, Alloy Surfaces Co, Alpha-Molykote Corp, Aluminum Co of America, Chromaloy Corp, Dow Metal Products Co, E I du Pont de Nemours & Co, Enjay Chemical Co, Haynes Stellite Co, International Nickel Co, Metal & Thermit Corp, Metco Inc, Minnesota Mining & Mfg Co, National Lead Co, Polymer Corp, Reynolds Metal Co, Arthur Tickle Engineering Works, Tin Research Institute, US Steel.

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EDITOR'S NOTE: Other articles that supply additional details on the functional aspects of metal finishes include:

Solid-film Lubricants for Extreme Environments, June 12 '61, p 70—How solid lubricants stand up to high temperatures and vacuums where others break down.

How to Choose the Right Electrical Insulation, Apr 10 '61, p 41—Comprehensive tables to aid selection of the best insulation from a wide range of organic finishes and other materials.

For a Stronger Metal Surface, Nov 14 '60, p 70—This practical guide compares the different methods of boosting wear resistance, bearing and fatigue strength.

Bonded Coatings Lubricate Metal Parts, Sep 5 '60, p 48—Latest performance data on cured-in-place coatings, including several new high-temperature types.

Today's Chrome Plate Finishes, July 4 '60, p 36—Relates performance and cost of new duplex chrome and nickel finishes to older chrome-plated combinations.

Aluminized and Chromized Coatings Change Steel Properties, June 27 '60, p 31—While they add to oxidation and corrosion resistance, data show how mechanical strength is also affected.

How to Specify Finishes for Magnesium, June 6 '60, p 31—Selection guide to the most suitable finish system, including chemical treatments and organic coatings for best properties at lowest cost.

Plating Parts by Peening Them, Mar 14 '60, p 70—Tumbling parts in a barrel is a low-cost way to give corrosion-resistant coatings of zinc and other metals.

Which Vinyl Coating Process for Metal Parts? July 6 '59, p 70—How to choose from the 4 basic methods for applying thick vinyl films.

Which Finish for a Zinc Diecasting? Mar 3 '58, p 59—Guide to Mechanical, chemical and plating and painting methods.

Porcelain Coatings on Steel, Feb 17 '58, p 75—Basic facts to simplify design of parts for the new one-coat porcelain enamels.

Hot-dipped Aluminum Coatings, Oct 28 '57, p 57—How the process allows you to substitute less-costly materials and reduce maintenance costs of finished parts.

Plated Finishes—The Choice Widens, Oct 28 '57, p 81—Electroplated alloys offer coating properties that single-metal deposits cannot match.

Vacuum Coatings Go Industrial, Dec 23 '57, p 67—Data on thicker coatings that have useful corrosion resistance and electrical properties as well as decorative appearance.

Fluidized Plastic Coatings for Corrosion Resistance, Jan '57, p 140—Describes powder dip process for uniform coatings on intricate parts; lists available coatings, their thickness ranges and applications.

Chromizing for Resistance to Corrosion and Wear, Nov '56, p 180—How gaseous diffusion of chromium produces either ductile or hard surfaces depending on the base steel composition.

Nickel Plating by Chemical Reduction, July '55, p 148—How electroless nickel plating can result in greater corrosion protection and more uniform plate thickness on intricate parts than electroplating.

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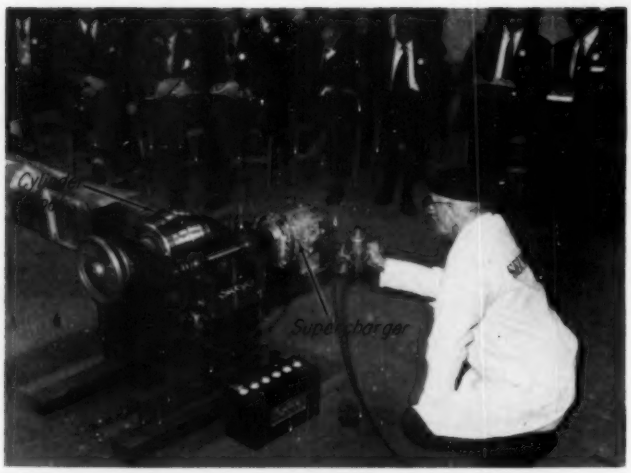
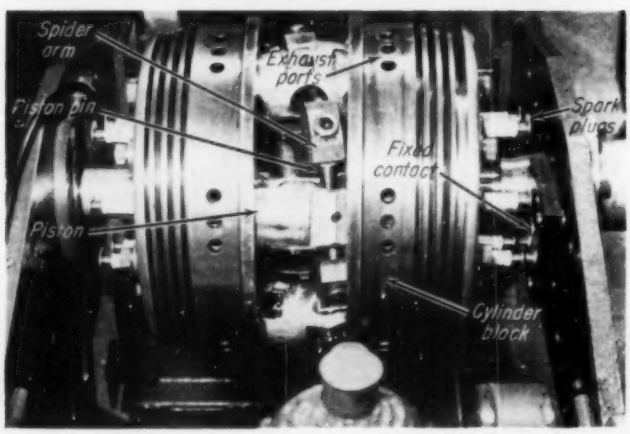
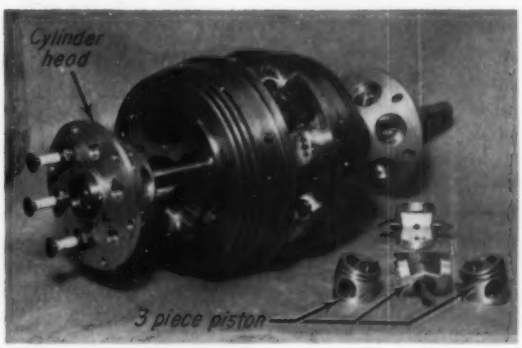
Spinning engine is vibrationless

Rotary engine has no crankshaft, flywheel or connecting rods, and pistons do not oscillate with respect to driveshaft. Combined assemblies of cylinder block, pistons and their connecting components are rotating masses dynamically balanced.

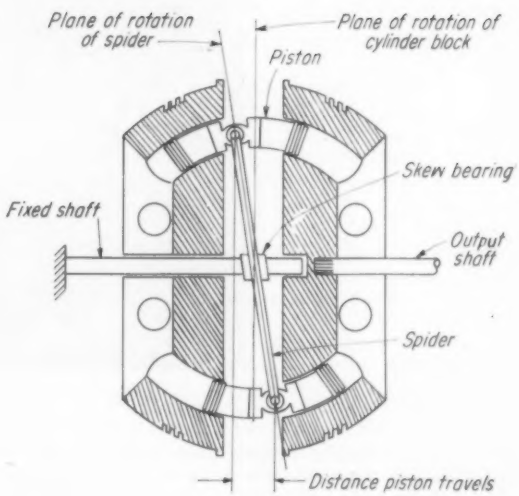






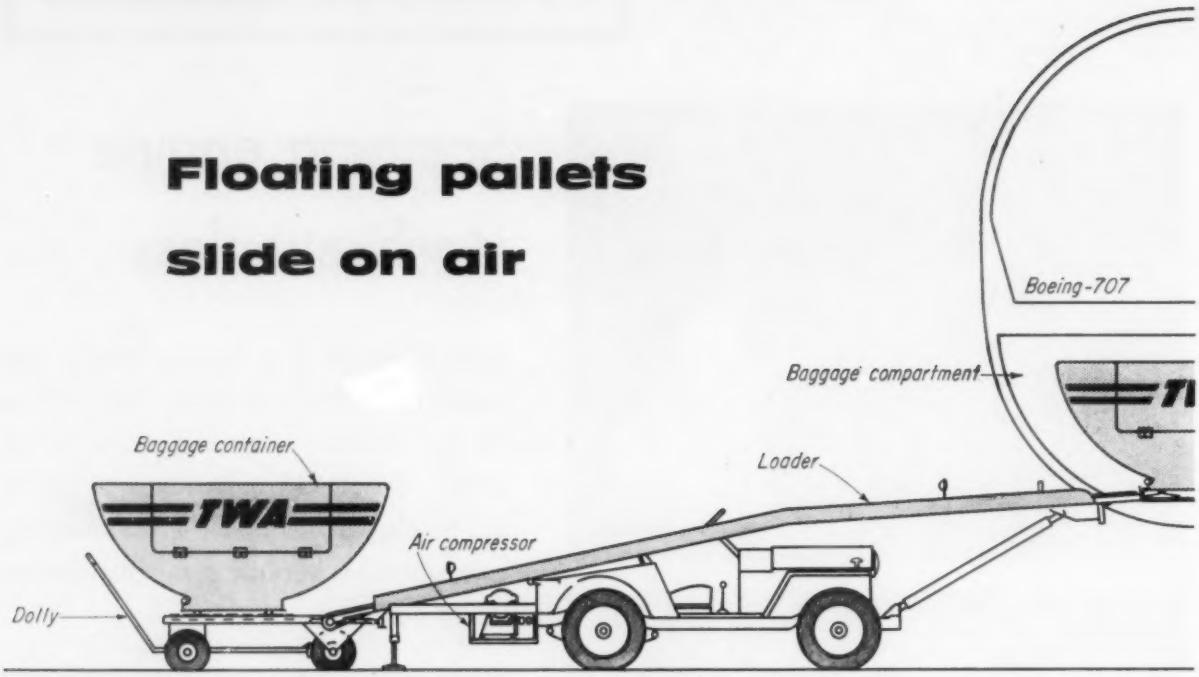
ROTARY ENGINE consists of an axially split block which rotates on a fixed shaft. Each half of the engine block contains six curved cylinders whose axis lie on the surface of a sphere. Six, double-ended, curved pistons are connected to a hexagonal spider, skew mounted on the fixed shaft. The pistons are mounted on piston pins clamped between the arms of the spider. Cylinder blocks and spider are linked together by the pistons and rotate as a single unit. The required reciprocating motion between piston and cylinder is generated by skewed spider as it rotates with the block. During one revolution of the two-cycle engine the six double pistons connected to the spider produce 12 power strokes.

Ignition is by spark plugs inserted in the conical cylinder heads which are bolted to the block. As the engine rotates the disks on the spark plug pass a fixed contact which fires the plug. Ignition can be advanced or retarded by moving the fixed contact. Air-fuel mixture reaches the cylinders through a passage in the fixed shaft on which the engine runs.

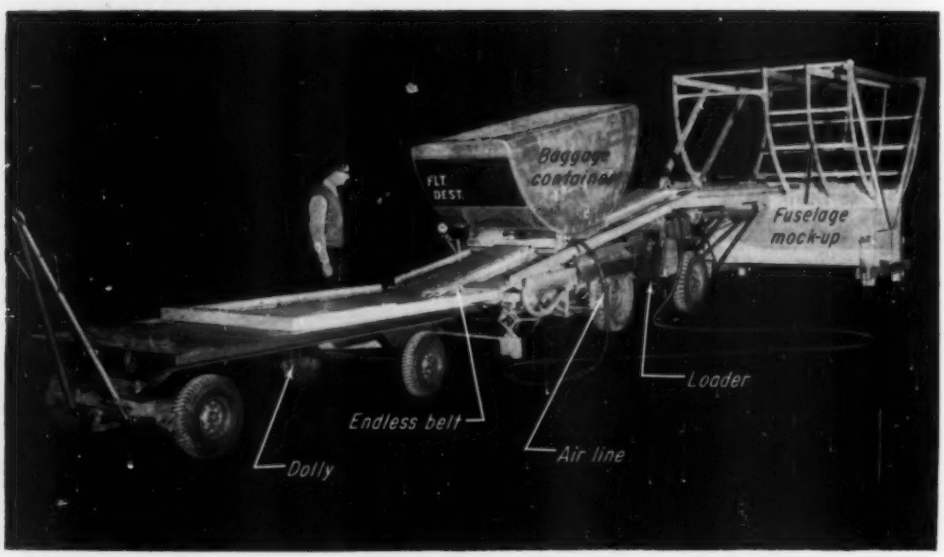


PS . . . The 12-cylinder, 2-cycle engine has six double-ended curved pistons operating in curved cylinders. A 1000 cc unit operating at 4000 rpm would develop approximately 70 bhp with a compression ratio of 8:1. Engine was developed by C. Hughes of William R. Sellwood Ltd, Chandlers Ford, Southampton, England.—John Tunstall, London.

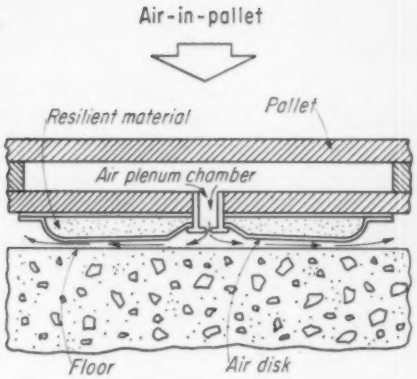
Floating pallets slide on air

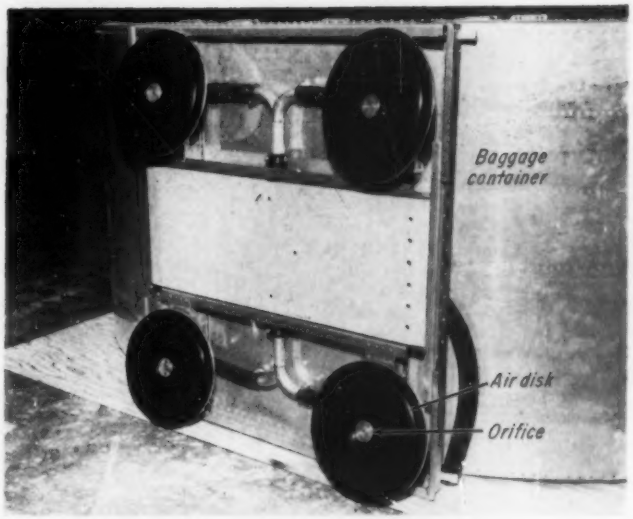


Ground-effect pads speed baggage handling for jet aircraft. Air cushion from pad or floor provides built-in braking, uniform floor loading, and simplicity of operation.



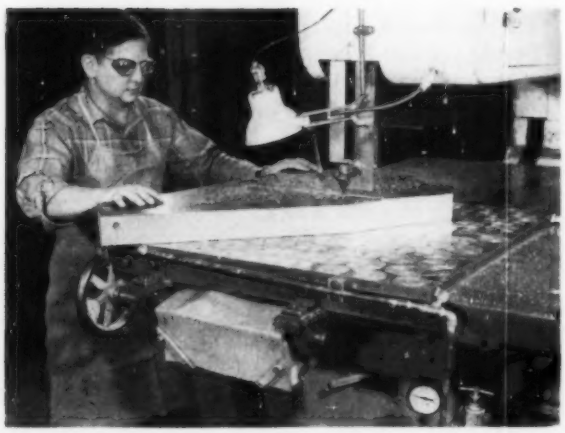
PS . . . Materials handling system permits movement of loaded pallets or containers with minimum effort in any direction. All-aluminum aircraft baggage containers 41 in. wide, 100 in. long, and 46 in. high are designed for a 1000 lb baggage load. Four swiveling Glide-Aire disks attached to the base support the container while it is moved from its dolly to the aircraft baggage compartment floor and positioned. Glide-Aire system was developed by Douglas Aircraft Co, Inc, Santa Monica, Calif. —JJK



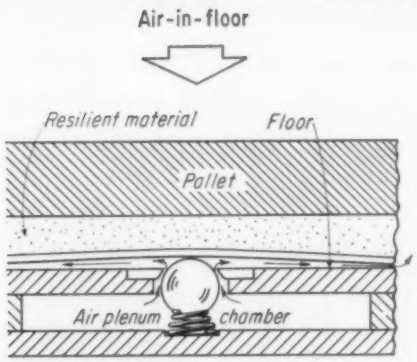


BAGGAGE CONTAINERS are supported by the air-in-pallet method. This system uses a plenum-type pallet with a number of resilient disks attached to the bottom. The disks are swivel mounted. The supporting cushion of air is supplied from the pallet through an orifice in the center of each disk. The 1000 lb container floats on a 0.015—0.030 in. cushion of air allowing one man to move it by hand.

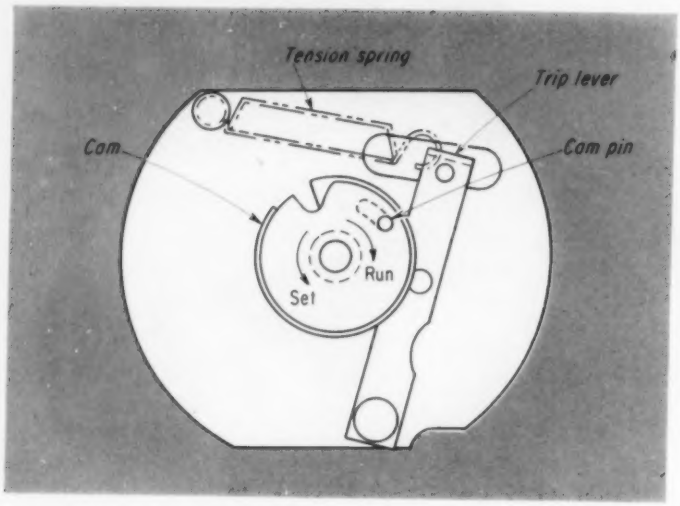
Each container is mounted on a baggage dolly designed to be hauled in a train from the passenger terminal to the aircraft. The top surface of the dolly is smooth to permit gliding the container from dolly to loader. Compressed air is applied to the disks via air hose from the Jeep mounted baggage loader. An endless belt is used to lift the containers from the dollies to the baggage compartment. The belt runs between the air disks and supports the container during its climb to the aircraft floor level. Modification to the aircraft included provision of a smooth floor to permit fore and aft movement of the container in the baggage compartment.



MACHINE TOOL APPLICATION of the air-in-floor system simplifies the moving of heavy materials on work surfaces. In this band saw installation an aluminum plate was studded with ball-check valves and supplied with compressed air through drilled passages. This permits the operator to move heavy stock easily and follow irregular patterns smoothly.



AIR-IN-FLOOR METHOD uses plenum chamber floor with resilient pallet bottoms. The floor is studded with a geometric pattern of spring loaded ball-check valves. The valve balls project slightly above the floor surface. When the pallet moves over the floor surface, the balls are depressed permitting sufficient air to escape and provide the necessary gliding cushion. The pallet can be moved in any direction as long as it remains in the area equipped with the air-in-floor system. Built-in-braking is provided by controlling the air supply. Pallets reaching the end of a line or ramp can be stopped smoothly by reducing the air pressure in steps until the pallet is no longer airborne. The flush-mounted air valves do not hamper pedestrian or valve balls project slightly above the floor surface. When compatible with other systems such as conveyor belts or rollers.



2-PART CAM is heart of this timer. Lower disk can move through a short arc relative to the upper disk which is attached to the shaft, mainspring and friction clutch. When turned, the upper disk lifts the follower out of the slot, then the cam pin picks up the lower disk and carries it around with it. The upper disk is rotated for the desired time interval. When released the dual cams return to their original relative position and present a sharp-edged slot for the follower to snap into.

for simplicity and reliability, don't overlook

MECHANICAL TIMERS

Continuous improvements in materials and design make them a good choice for triggering one or two sequential operations.

FREDERICK MARICH, *assistant editor*

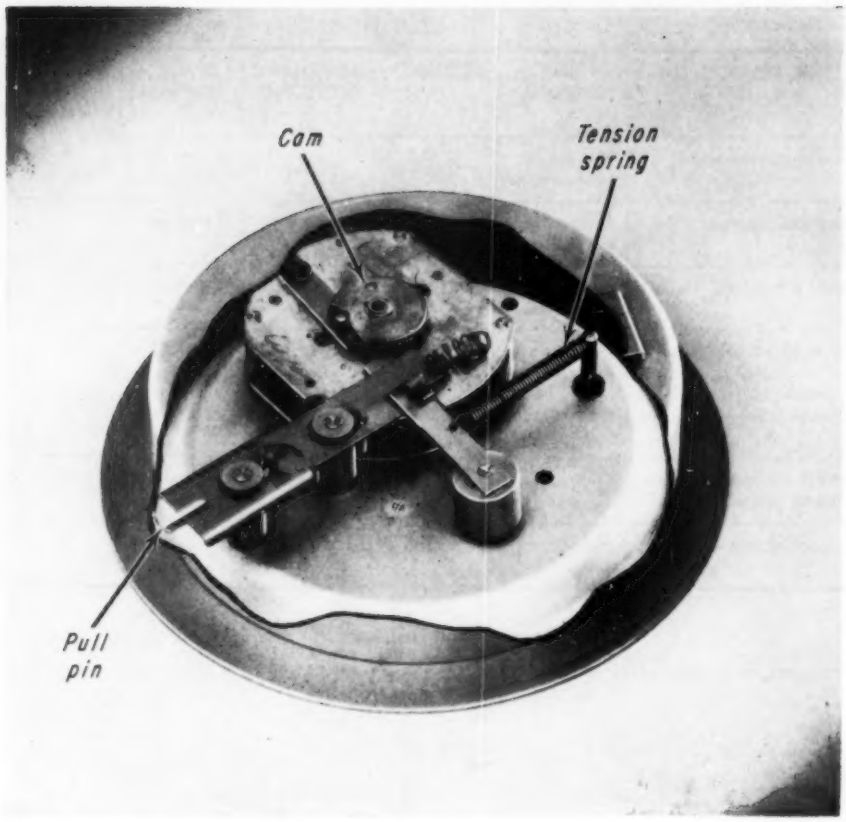
Mechanical timers are based on the clock escapement, which has had a long history of development. Accordingly, they can be designed to operate as accurately as the application may require. They can be made to fit into a wristwatch or deliver a blow as powerful as a trip hammer.

The mechanical timer is usually a standardized unit built into a special housing to suit the application. It consists of a cam fixed to a mainspring and clutched to a gear train regulated by a clock-escapement mechanism. The cam follower—with its own tension spring—acts as the "trigger" for any desired function. It may ring a bell, close a switch, or set off an explosive charge that releases quite large amounts of stored energy.

Heart of a mechanical timer is its mainspring. This can be made of ordinary high-carbon steel, which has good endurance and mechanical characteristics as well as resistance to stress-corrosion cracking and fatigue. For applications requiring many thousands of cycles, however, the carbon-steel mainspring is not reliable enough.

The mainspring can also be made of special alloy steel, such as Havar (Hamilton Watch Co) or Elgiloy (Elgin Watch Co). This type of "unbreakable" mainspring has practically eliminated failure in mechanical timers.

The time interval possible with mechanical timers is very flexible; it can be a few seconds or up to 12 hours. Most commercial applications have a range of either a few minutes or a few hours with any desired adjustability.



PULL-PIN LOCKS CAM FOLLOWER "out" and simultaneously jams gear train so that the timer is cocked and ready to start its cycle at any time. This unit is mounted on, and locks, the cover of a radiosonde stabilizing parachute container. When the assembly starts its fall, the pull-pin releases the gear train and the cam follower eventually frees the parachute.

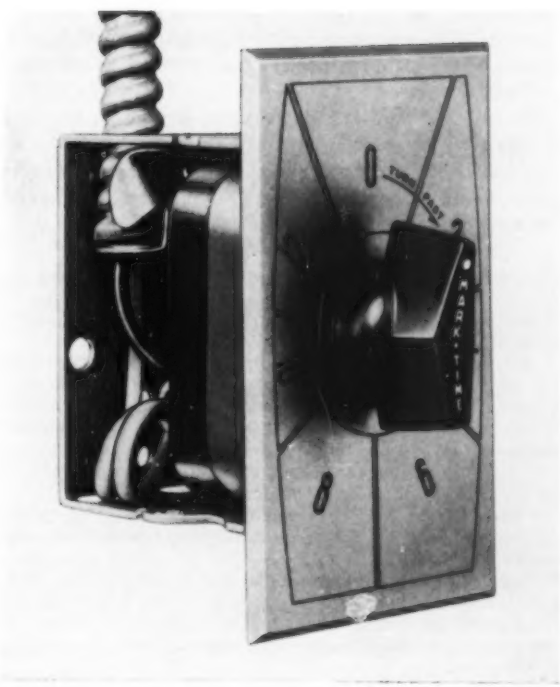
Time intervals of a few seconds are achieved by attaching the cam mechanism to the "seconds" (high-speed) gear in the clock mechanism, which is omitted in timers that mark only minutes and hours. Similarly, intervals of more than 12 hours are clocked by attaching the cam mechanism to a still slower gear in the clock mechanism.

Accuracy is a function of workmanship and comparable to that of any watch mechanism. For most commercial applications, accuracy ranges from 0.5 to 5% of the time interval.

Automatic recycling of a mechanical timer is possible, but generally other timing devices are more suitable where manual resetting is objectionable. This is particularly true where programming of multiple automatic operations is needed. Mechanical timers may be reset by a solenoid. This can be just as effective as manual resetting, but may not be as economical as using timers more readily adapted to recycling.

Space requirements are usually a function of the amount of energy that needs to be stored in the tension spring, and the manner in which the cam and trip lever are to be actuated. Where the timer closes a switch, the timer is most conveniently packaged to fit a standard electric wall box.

Cost of mechanical timers depends on the accuracy required and the special features, if any. Generally, the timer will cost from about $1 to $20. Simple pyrotechnic-



SWITCH ACTUATOR fits neatly in electric wall box. Time here may be set for any switch closing up to 12 hours.

CHARACTERISTICS OF TIMING DEVICES

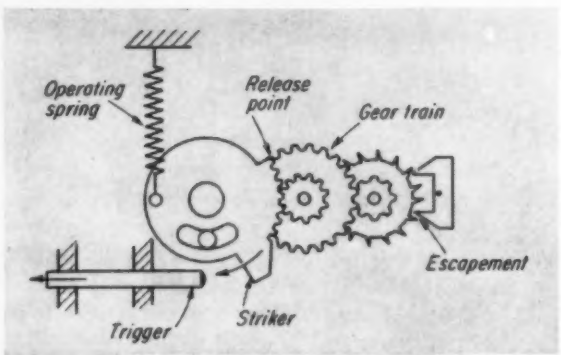
TYPE	METHOD OF TIME DELAY	TIME INTERVAL	ACCURACY, %	AUTOMATIC RECYCLING	SPACE, CU IN.	RELATIVE COST (1 = lowest)
Mechanical	Gear train and escapement govern speed of spring motor	Several sec to several hr	0.5–5	No	0.5 to 50	3
Pyrotechnic-chemical	Rate of combustion or chemical reaction	Millisec to several days	25–50	No	5 and up	1
Thermal	Metal strip deflects as heat is applied	Millisec to several min.	10–50	Yes	0.5 to 5	2
Dashpot-pneumatic	Bellows action as air or fluid passes through orifice	Millisec to several min.	10–20	Yes	10 to 50	6
Synchronous motor	Gear train provides reduction from synchronous motor speed	One min. to several days	0.5–2	Yes	20 and up	5
Dc motor	Gear train, with or without escapement, provides reduction from dc motor speed	One min. to several days	0.5–20	Yes	10 and up	4
Electronic	Charge or discharge rate of resistor-capacitor network.	Millisec to several sec	1–5	Yes	20 and up	7

chemical and thermal units can be cheaper, but obviously are less versatile.

Double-operation timers

Mechanical timers of commercial quality can also be adapted to timing of two sequential operations in one cycle. Usually this is done by arranging two cams in series with simple friction clutches, or a special gear segment and cam arrangement. Timing of the first operation is determined by the angular displacement of the gear segment. The second operation is performed as fast as the inertia of the load and the remaining energy in the spring will permit.

Sometimes, this second operation is used to trigger an auxiliary spring or mechanism, as in photo below. The multiple-operation timer that releases spring energy in more than two steps is generally considered impractical for conventional timing jobs.



DOUBLE-OPERATION TIMER regulates a first operation for a predetermined time interval until striker contacts trigger. Then trigger is pushed with remaining spring energy.

EDITOR'S NOTE: We are grateful to M. H. Rhodes, Inc, Hartford, Conn., for much of the information used in this article; for more on design of mechanical timers and on alternate types see:

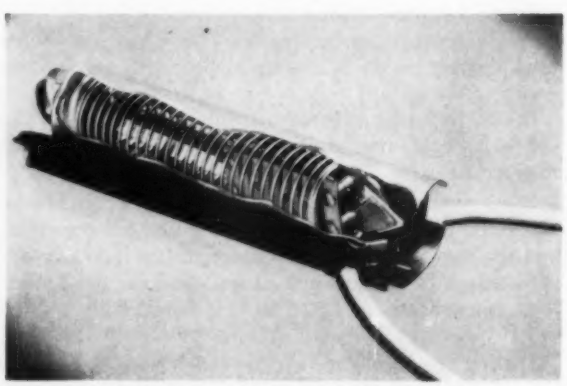
"Operating Principles of 13 Timing Devices," Mid-Sep '60, p 393—Describes all types, from pneumatic to electronic timers. Includes time range, accuracy, and type of output.

"Clock-escapement Mechanism," Jan '57, p 179—Describes the heart of the mechanical timer—with formulas, curves and typical applications, including torque regulators, accelerometers and velocity indicators.

"Your Choice of Recycling Timers," Aug 8 '60, p 48—Evaluates 5 types that are recommended for recycling operations.

"Which Decision-making Electrical Control," Feb 13 '61, p 37—Special report gives comprehensive details of electromechanical, semiconductor, and magnetic relays used for controls on machinery, communication devices, and data processing.

"Timing Machine Operations with Small Thyratrons," Nov '50, p 85—Design details of economical electronic timer built around thyratron tubes.



SIX-SEC INTERVAL TIMER releases powerful spring which cuts parachute reefing line.

IS YOUR INVENTION PATENTABLE— AND WORTH IT?

Don't wait until your new product or invention is ready to market—and then start a last-minute scramble for a patent. You'll be asking for trouble in two ways: you may not receive adequate patent protection, or you may buy a patent that you don't really need. In either case, you're wasting money.

HUGO WIKSTROM, *patent attorney, New York City*

■ The way to save money is to think about a patent when you're evaluating the development—when you've got a prototype in hand, or a firm concept on paper, and you're trying to decide whether or not to go ahead. Here's why:

• You determine the invention's worth by providing a forced, critical study from a new angle.

• The preliminary search may uncover similar inventions that have not been marketed for some reason. This can help avoid what happens all too often in organizations having poor patent programs. They apply for a patent after the new or improved product has been fully developed, then discover that it is impossible to patent. Or worse, that someone else has already patented it.

• The preliminary search may show that even though the new product will be novel, several of the divergent paths open to investigation have been followed by other people. The search will provide a detailed explanation of

WHY SEARCH THOROUGHLY?

Because the applicant for a patent must give assurance that everything in his application is new he must know all the prior art—not just patents in force. If something claimed as novel has been used before, the patent can be invalidated.

Doesn't the Patent Office search the art? Yes, but the examining corps of the Patent Office totals about 1200 men. The patent backlog is 190,000 applications (as of Jan 1961) and 6700 new applications are filed each month. The examiners cannot take the time for an extensive search.

The usual procedure, which is backwards of course, is that pre-file searches are "quick and dirty," but when an adverse (to your competition) patent appears, he turns loose an army of searchers with instructions to search back, even to the Egyptian hieroglyphics if need be.

why they were not successful and will steer you into the paths which promise the best protectable return.

• The patent can be custom-tailored to the invention. Patent costs vary according to the amount of protection you need and this is the time to determine how costly the patent will be.

• Once the approximate patent costs are known, they can serve as a basis for sound business decisions–and be budgeted along with development costs.

Why costs vary

There is no such animal as a "standard" patent, costing X dollars. Each invention must be judged on its own because it will have unique marketing possibilities as well as development costs and, like development costs, patent costs vary with the amount of effort put into the program. The efficient patent program gears the amount of effort spent with the amount required. The trick is to determine the effort required.

It's fairly simple to determine that maximum effort is required. For example, Berle and deCamp in *Inventions, Patents, and Their Management* tell the story of H. James Rand and his washing machine. Because his invention promised long-term returns and would enter a market dominated by giant corporations, Rand decided on maximum effort.

He hired three different patent attorneys to make independent searches. A competent firm prepared the application after a study of the searches, then a second firm was hired to review the application–as if it were a competitor trying to break or evade the application. The second firm's report on weaknesses was used to redraft the application. The resultant patent was never attacked.

This "maximum effort" cost $30,000. But Rand sold an option on the patent for $149,000, then received an additional $500,000 in cash plus a minimum royalty agreement of $200,000 a year (if earned) for 20 years. The Bendix Home Appliance Co marketed the machine as the Bendix Economat.

Rand's is an unusual case, but it points up the value of early patent evaluation so that the patent can be planned as part of the keel-laying process instead of, as in many cases, part of the ceremony of cracking the bottle of champagne across the bow when the ship is launched.

The opposite extreme–that of not requiring patent protection–is also fairly simple to determine. If the returns will be short-term and development expense low, such as with hula hoops, you ordinarily needn't bother with a patent. By the time your patent position can be developed, the fad is over.

The large area between the extremes of maximum and no effort (most cases) is where business judgment must be an important part of the evaluation. If the inventor knows the prior art from previous patent experience and searches, he can reduce patent cost considerably. One recent case involved the development of a new chemical process by inventors who did know the prior art from previous patent experiences. The application was prepared and filed for a total cost of $350. On the basis of the application, the inventors raised $750,000 to build a factory for the production of chemicals in accordance with their process.

Not everyone knows the prior art. One inventor, working on a wire transport for computer read-in, made a fairly thorough investigation of available equipment and of computer literature, and assumed he had a clear field. One man-year of engineering later, the patent attorney was called in. He made a search which uncovered an identical structure invented about 100 years ago to handle a tricky threading problem in fabric mills. Patent possibilities went out the window. An early evaluation (which includes a patent search) might have saved that man-year of time.

A case being tried right now involves a process for making printed circuits. The prior art being cited is from the 1700s. Someone at the time made glass globe lamps containing a fancy copper design by etching the copper from a pattern.

The problem of searching the art of different fields for related problems is large and becoming larger. Patents are now classified in over 50,000 subclasses. This means a good strong patent takes a lot of searching and a lot of ingenuity on the part of the searcher. Careful early evaluation will save money by limiting the extensive search to the few occasions when it's really needed.

However, if you do need a strong patent and don't spend the money for an extensive search, you can bet your competitor will when you start suit. Don't let yourself get caught in the following hypothetical situation:

You file an application without adequate investigation. You license several companies to make your product and royalties start to roll in. Then an unlicensed company starts manufacturing an identical product. When you start waving your patent, he produces prior art which was unknown to you. Your claims are too broad in view of the art, even though they did not need to be so broad to cover the invention. Now you are faced with a dilemma. If you don't sue, your licensees will stop paying royalties, yet, based on your knowledge of the unlicensed competitor's strong position, you know you will probably lose. So you sue, in the hopes that a judge will interpret your claims to escape the prior art, and still cover the invention. The cost–tens of thousands–just to save a relatively small search expense.

A guide to evaluation

Each company or individual should establish his own patent evaluation program. It needn't be highly structured or formal, although it can be, but questions must be asked about market potential, expenses, etc, and at the correct time. Many companies have set up criteria for new products (certain predetermined conditions must be met, such as a minimum percentage return on sales, etc). The individual professional inventor doesn't usually rely on formal steps, but he does evaluate.

In addition to the usual criteria that go into market evaluation, these patent factors should be considered:

• The novelty of the development. Adequate budgeting for necessary searches should be made.

• An evaluation of possibility of infringement of proprietary rights of other parties.

TYPICAL PATENT RATING SCALE

Development Rating	Explanation of Rating	Preliminary Patent Budget
A	Several development paths open; high development expense anticipated; long-term returns possible.....	$3000
B	Low development expense; long-term returns possible	$2000
C	Low development expense; major technical advance; returns not predictable at present	$1000
D	Improvements — patent consideration only involves over-all patent position..	$500
E	Returns independent of patent aspects.	....

• Estimated costs of patent program which will be added to development costs for budgeting.

In early stages, information can be broad, general. A quick and inexpensive search at this stage often prevents further expenditures of development effort. As the need for more exact information increases, precision of evaluating can be increased. By knowing the costs of the program, the necessary money can be budgeted in advance, and be available when necessary. Whether you are head of a new product group and must sell top management on the need for funds, or an individual inventor trying to raise financial backing, it is easier to raise the total cost of the project in one chunk, than to keep coming back for smaller bundles of money as unforeseen expenses arise.

The accompanying table shows a rating system used by one medium-size corporation as part of its internal patent program. Periodically all inventions are evaluated for the purpose of selecting the few for further development. At this time the developments are rated simultaneously on the rough patent scale and budgeted for anticipated patent expenses. If you decide to make a similar table to rate your new products, be sure to scale the budget figures to your own needs. ■

WHY ARE 70% OF SUITS WON BY DEFENDANT?

Don't be deceived by statistics. The strong, properly prepared patents are not contested, and so only the marginal patents reach court. The plaintiff (inventor) and defendant have reached opposite conclusions as to the effect of the patent and have asked the court to decide. On this basis alone the ratio would be 50:50. The ratio is still loaded, because the plaintiff is more often forced to sue on a doubtful patent. When competitors start to make his product, he is often forced to sue to stop mass competition. Defendants, however, can to a greater extent pick which patents they wish to contest. Thus the ratio is 70:30.

EDITOR'S NOTE: One element of a complete product evaluation is patent protection, as detailed above. For the rest of the story see:

Does Your New-product Idea Measure Up? May 9 '60, p 56—Among all the candidates, how do you choose the "right" one? Authors present a technique that cuts guesswork—analyzes a number of promising ideas throughout their development, then methodically eliminates the weaklings that can't meet predetermined standards.

The Yardstick for Research Success, Oct 19 '59, p 35—Discusses three indices of new-product profitabiltiy: return on total sales, return on investment, and cash flow.

A Dollar-and-Cents Evaluation of New Products, June 29 '59, p 21—Offers a system based on four parameters: average development cost per year, years of development time, average profit per year of product life, years of market life.

The Economics of Research and New-product Planning, March 9 '59, p 42—Stresses importance of objective analysis. Shows how three different companies tackle the problem.

Pre-development Planning: Four Steps to Low-risk Products, Aug 11 '58, p 32—Tells how these steps, if they precede product acceptance, will narrow the choice to the few ideas with better than average chance for success.

Product Development, a Running Start, Sep '55, p 179—Presents the case for an efficient, well-organized product-planning committee—to control accumulation of data, performance specs, cost estimates, sales volume, and service life.

—Frank Hall

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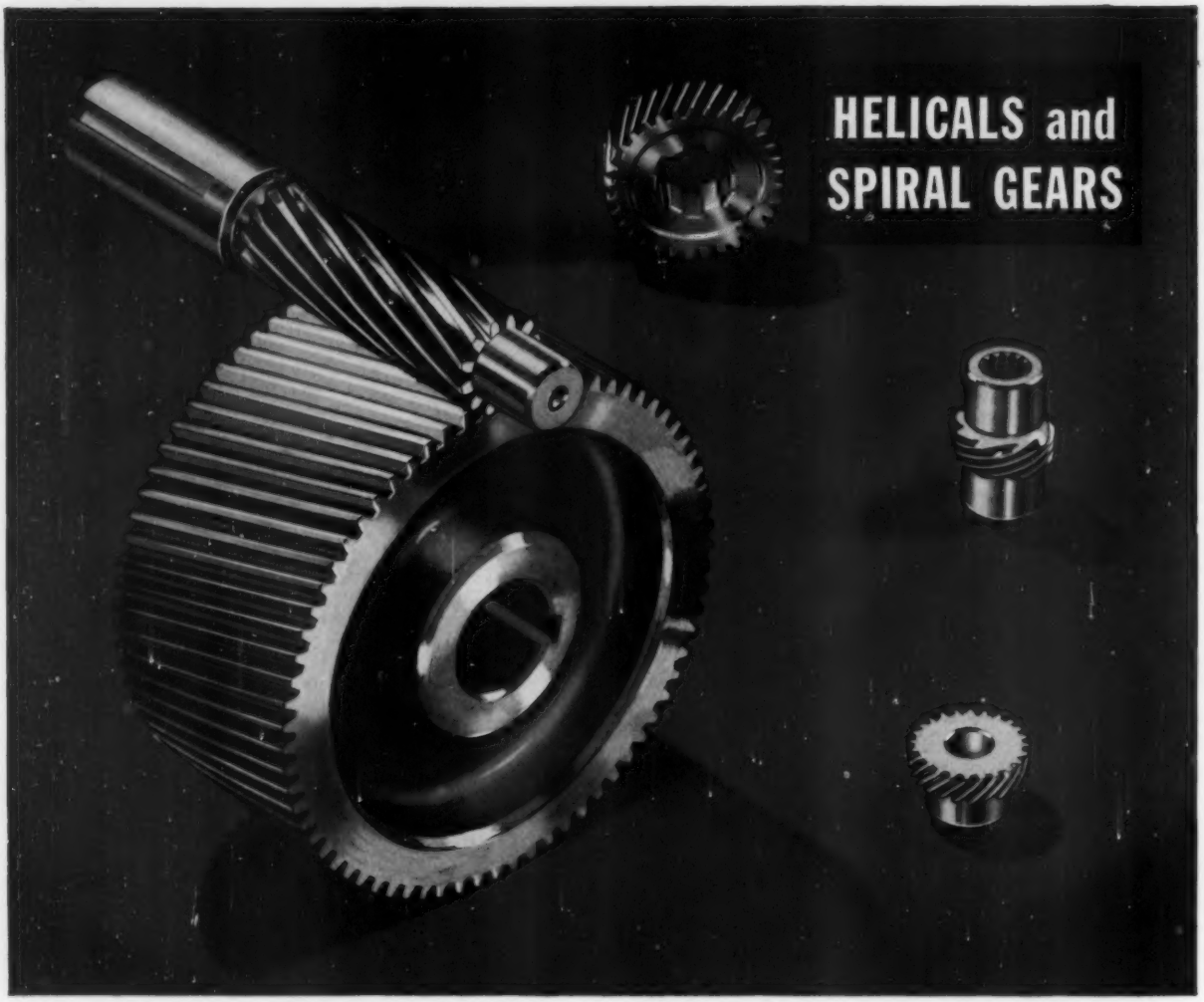

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DESIGNING FLAT SPRINGS —width and thickness

Simplifying factors fit 8 types of single and laminated flat springs to same nomographs. Two more nomographs, covering spring rate and unit resilience, will appear in the July 31 issue.

WILLIAM GRIFFEL
Ordnance engineer
Picatinny Arsenal

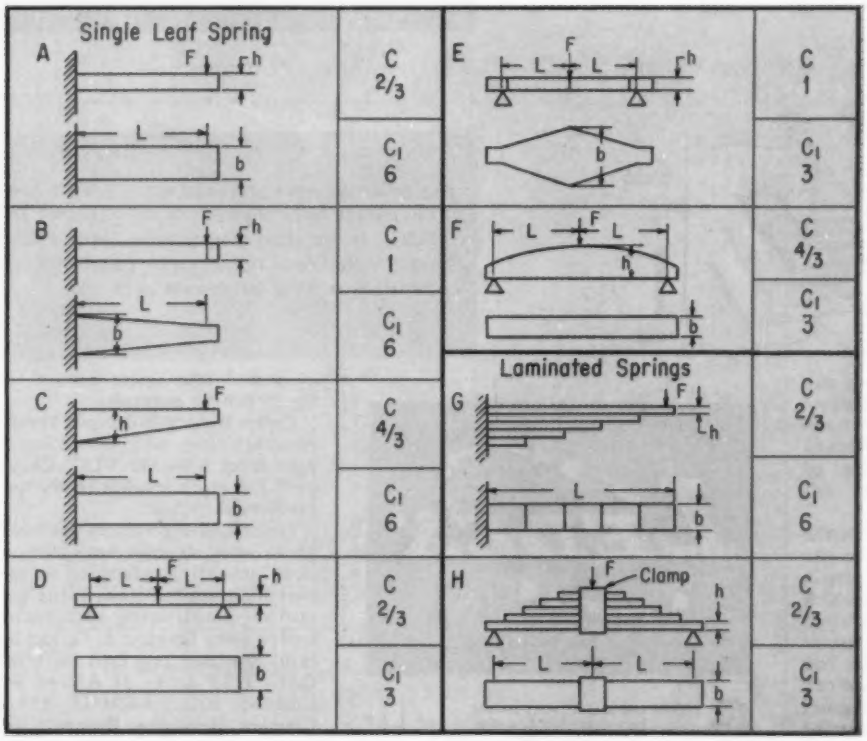
Flat springs are like beams. Their common configurations correspond to the cantilever beam, simple beam or constant-strength beam. Springs with constant strength have varying thickness or width, so that a load produces the same stress at every cross-section. As a result, they are lighter and can deflect farther than a spring with a uniform cross-section and the same strength.

When a single spring is too wide, a narrower laminated spring can be used instead. Since it approximates the shape of a constant-strength beam, the laminated spring gives long travel combined with high strength.

The nomographs below solve for thickness $h = CSL^2/Ey$, and width $b = C_1FL/Snh^2$. Thickness and width factors shown in the table fit all eight springs to the nomographs.

EXAMPLE I: A Type E steel spring will carry a 750-lb load without deflecting more than 1¼ in. Max allowable stress for the material is 50,000 psi; modulus of elasticity is 30 x 10^6. If the spring is 26 in. long, how thick and how wide will it be?

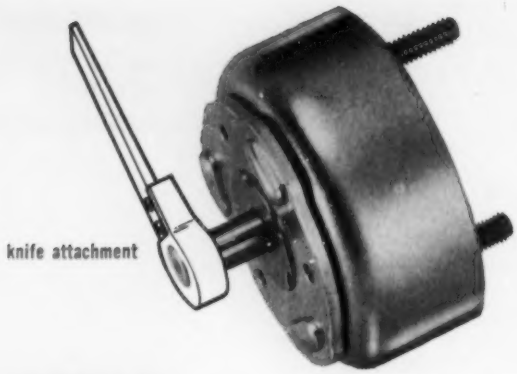
Solution: From the table, under Type E, $C = 1$, $C_1 = 3$, and $L = 26/2 = 13$. Draw four lines on Nomograph I to find spring thickness $h = 0.22$ in. Continue on to Nomograph II and find width $b = 12$ in.



SYMBOLS

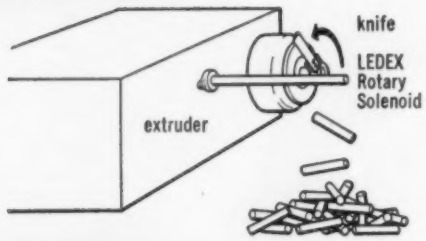
- b = Width of flat spring, in.
- C = Thickness factor
- C_1 = Width factor
- E = Modulus of elasticity, psi
- F = Load, lb
- h = Thickness of flat spring, in.
- L = Length of cantilever spring; half-length of simple beam spring, in.
- n = Number of leaves
- S = Maximum allowable stress, psi
- y = Deflection of spring, in.

continued, page 63



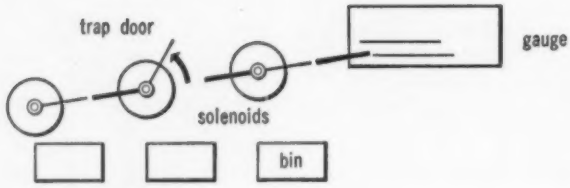
Compact Solutions with Ledex Rotary Solenoids

CUTTING



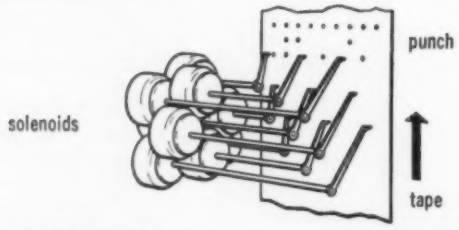
In this example a Rotary Solenoid has a knife attachment for cutting a plastic material that is extruded continuously. The speed of the solenoid is so fast that the material needs no additional support.

SORTING



Here parts to be sorted first pass through a gauge. The gauge measures size of part and activates a Rotary Solenoid to open a trap. Sorting could be by size, weight, electrical capacity, or other type of quality control.

PUNCHING



The quick snap action of a Ledex Rotary Solenoid (about 1/25 second) meets requirements for high-speed tape punching. In this example, solenoids have arms attached to shaft extensions of varying lengths, permitting a compact nest of solenoids that requires small space.

The examples shown above have one thing in common. They fit into compact space. Design engineers, for example, often find that a Ledex Rotary Solenoid will fit into one-quarter to one-half the space of a straight pull solenoid.

This compactness results from the unique Ledex design which converts an efficient short axial stroke into a high torque to size rotary motion. A more uniform force is produced throughout the stroke, making use of otherwise wasted energy at the end of the stroke. This rotary motion can be used directly as in the cutting and sorting examples above, or can be converted into linear motion, as in the punching example.

Ledex Rotary Solenoids come in 8 compact sizes, with operating voltages from 3 to 350 VDC. Choice of over 250 stock models ready for immediate shipment.

Other Ledex products are ready to go to work as compact solutions to your actuating, stepping or circuit switching applications. Write for literature mentioning application to Ledex Inc., Dayton 2, Ohio; Marsland Engineering, Ltd., Kitchener, Ont.; NSF Ltd., 31 Alfred Place, London, Eng.; AEMGP, 115 Ave. Clement, Boulogne, France.

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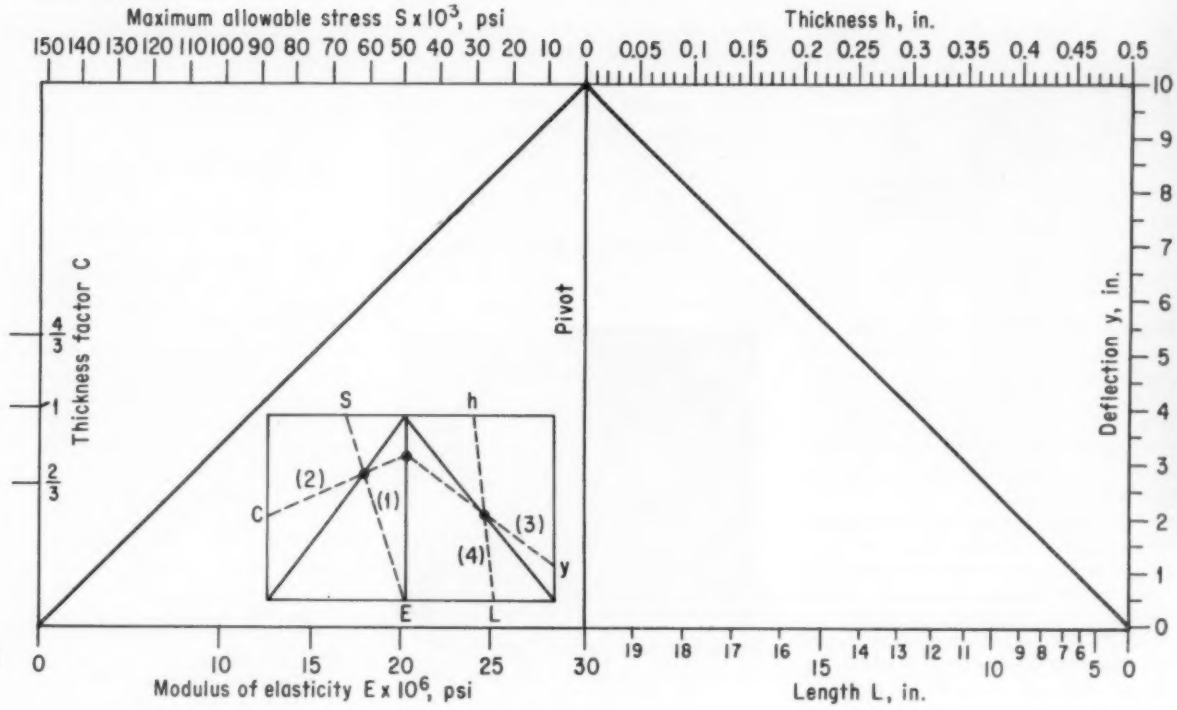
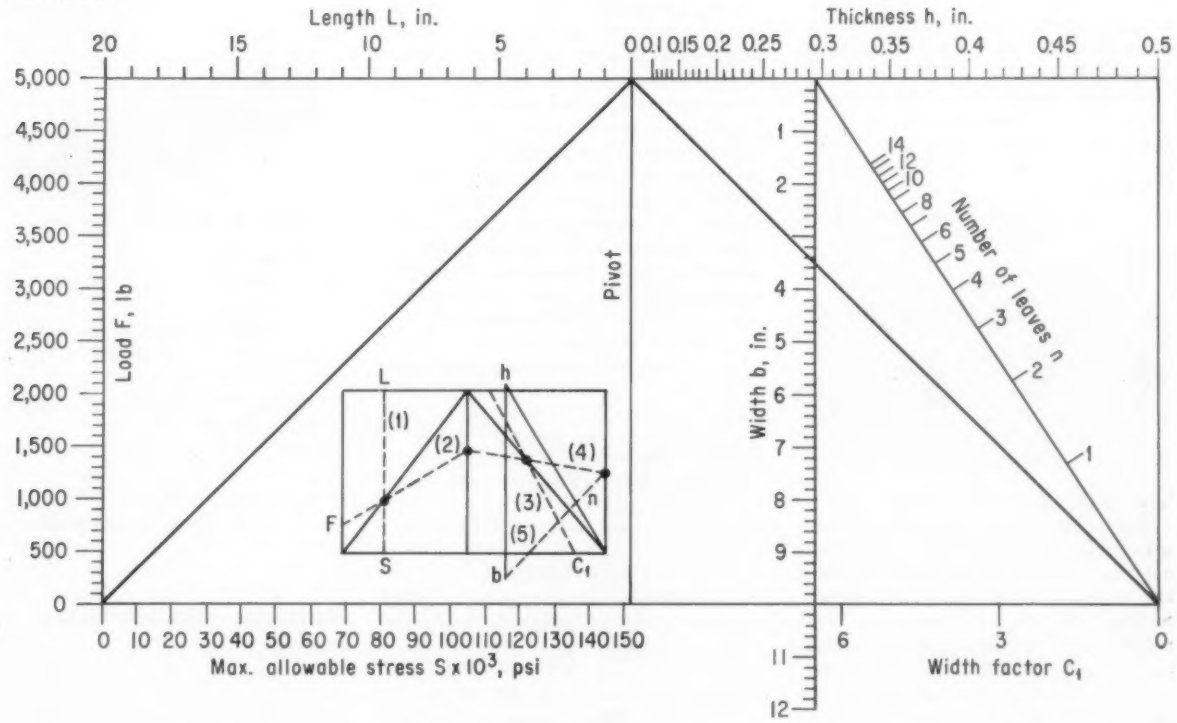
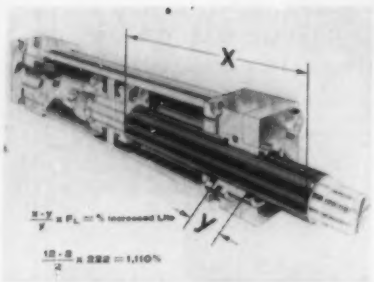
I—THICKNESS



II—WIDTH



SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



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Self-locking cable strap . . . is inserted in a blind mounting hole and securely locked by thumb pressure without tools. Metalized gray plastic construction is said to provide high electrical protection; chemical, corrosion and wear resistance; and high strength and vibration characteristics. Installed strap seals mounting hole. Available this summer will be six stock sizes that mount in ¼- and ⅜-in. holes, support ¼- to ⅝-in. cable and lock into ⅛-in. panels. Currently from stock: two sizes that mount in ¼-in. holes—one which supports ¼-in. cable and other, ⅞-in. cable. Price per 1000 units will range from $10 to $19. Now-in-stock sizes are priced at $13 and $16 per 1000 units. **Budwig Mfg Co, PO Box 4212, Glendale 2, Calif.**

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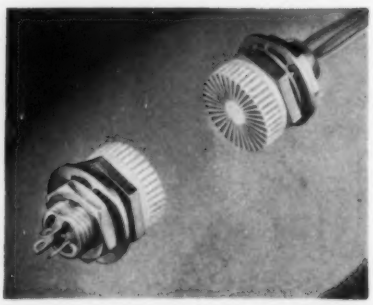


Minaturized potentiometer . . . has electrical element in front of mounting panel, entirely contained within operating knob. Knob also functions as moisture- and dustproof housing for unit. Terminations—either wire leads or solder lugs—are brought out through rear of mounting bushing and are sealed. Available in resistance range of 10 to 10,000 ohm, wire-wound unit is rated at ½ w at 104 F. Taper is linear. Resistance tolerance is ±10%, unless closer tolerance is specified. Needs no additional gasketing or encapsulation for installations requiring weatherproofing. In pressurized equipment, unit forms seal with mounting panel without need for bellows assemblies. Priced at approx $2, depending upon quantity. Delivery is normal cycle. **Clarastat Mfg Co Inc, Dover, NH.**

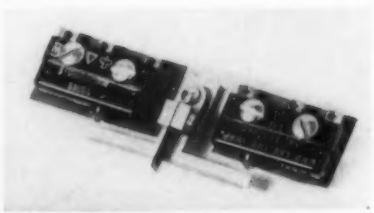
Circle 302 on Reader Service Card

Buffed stainless strip . . . has highly reflective finish on both sides. In-line buffing after processing is said to produce not only uniform finish, color, shading and reflectivity but also improve corrosion resistance. Available in coils up to 26½ in. wide, thicknesses from 0.012 to 0.080 in. at no increase in price over common stainless steel strip. Delivery ranges from stock to 4 wk. **Universal-Cyclops Steel Corp, Bridgeville, Penna.**

Circle 303 on Reader Service Card

Servo-controlled galvanometer replaces usual D'Arsonval-type force balance system with a position-sensitive servo system employing a precision potentiometer. Signal fed into the device is compared to a voltage obtained from the feedback potentiometer. If the meter movement position does not correspond to the position called for by the magnitude and polarity of the input signal, a difference voltage or error exists. This error then is amplified by a self-contained transistor-equipped amplifier which drives movement. Response of 50 millisec is achieved, since system operates with substantially higher torque-to-inertia-ratio than conventional servo system. Power required for position indication is 1 w; max accelerating power is 1.5 w. Full scale accuracy is stated at 0.25% in any position. Unit allows for continuous reading electronic meter-relay action with full-scale dual limit settings. There is said to be virtually no dead zone at limit positions, and a tight repeatability of 0.15% is achieved. Delivery in 4 to 6 wk. **Computer Instruments Corp, Servometer Products Div, 92 Madison Ave, Hempstead, NY.**

Circle 304 on Reader Service Card



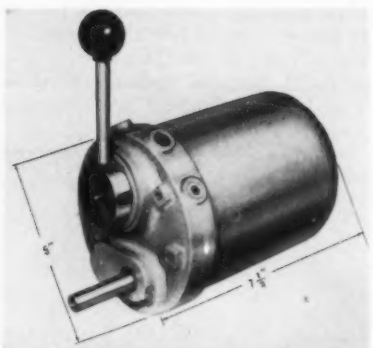
Limit switch . . . can be adjusted from 20° to 370°. Flat spring fastened to T-lever can be overridden without being overstressed. Operating torque is 0.5 oz in. and capacity, 5 amp, 230 v ac. Priced at $24.50 each in quantities of 1-9; $22.05 each in quantities of 10-24; $19.85 each in 25-49 quantities and $18.85 in 50-99 quantities. Delivery ranges from stock to 2 wk. **Gap Instrument Corp, S. Main St, Newton, Conn.**

Circle 305 on Reader Service Card

Neoprene-asbestos gasket material . . . is for service against hot or cold oils of various types in fuel, lubrication and hydraulic systems. Has compressibility of

35% at 1000 psi and 45% at 5000 psi, which is said to compensate for rougher flange surfaces than can be tolerated normally. Despite high compressibility, material reportedly has excellent resistance to stress relaxation and resultant loss of bolt torque. Typical properties include: longitudinal tensile strength, 2100 psi; transverse tensile strength, 1100 psi; thickness increase in ASTM oil No 3, 5 hr at 300 F, 5%; and flexibility factor, 16 hr at 280 F, 10. Supplied in commercial quantities at price about 60% as high on an area basis as beater process neoprene-asbestos sheet currently available. **Rogers Corp, Rogers, Conn.**

Circle 306 on Reader Service Card



Hydraulic power unit . . .

is completely self-contained control comprising a hydraulic gear pump, relief valve, 3- and 4-way control valves and tank. Pump delivers up to 2½ gpm at pressure to 400 psi and shaft speeds to 1800 rpm. Tank has capacity of 0.4 gal., with additional oil capacity available to system when double-acting cylinders are used. Less than ½ hp operates unit at max pressure. Measures 5 in. OD and 10⅜ in. long, including shaft extension from end cover. Requires less than 160-cu-in. space when installed and weighs less than 10 lb (dry). **Hein-Werner Corp, Waukesha, Wis.**

Circle 307 on Reader Service Card

Stainless steel spring wire . . .

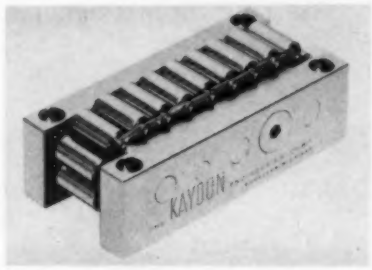
has tensile strengths up to 100,000 psi higher than music wire in 0.075-in. size. Min tensile strength of 0.195-in. material is 290,000 psi, compared with 245,000 psi for music wire of that size, while tensile strength of 0.004-in. material is 500,000 psi, compared with 439,000 psi for music wire. Tests using 0.125- and 0.075-in. wire on automatic coiling machines show that a spring index as low as "3" can be achieved without breakage. Stainless wire is an unbalanced semiaustentic alloy originally developed for heavy wire sections fabricated from bar, billet or plate stock. Typical analysis is: 0.142% carbon, 1% manganese; 0.027% phosphorous, 0.013% sulphur, 0.32% silicon, 15.65% chromium, 4.38% nickel, 2.68% molybdenum, 0.12% copper and 0.124% nitrogen. Modulus in torsion at room temp is 11 to 11½ million psi. Density is 0.282 lb/cu in. Modulus of elasticity ranges from 29.3 million psi at 80 F to 24.6 million psi at 800 F. From stock in diameters from 0.003 to 0.195 in. **National Standard Co, Dept RDT, Niles, Mich.**

Circle 308 on Reader Service Card

Rapid curing epoxy adhesive

cures in 60 sec at room temp and can be accelerated to 45 sec with use of infrared heat. Suitable for automatic meter-mixing-dispensing units in rapid production line work and bonds metal to metal, plastic to metal, plastic to plastic or any other porous or nonporous surfaces. Available in 8-oz trial kits at $6. **Allaco Products, 238 Main St, Cambridge 42, Mass.**

Circle 309 on Reader Service Card



Recirculating roller bearing

has coefficient of friction as low as 0.00025 under 500-lb load and 0.25-in.-per-min. linear motion—or ⅛th that of other bearings of this type. Designed around a recirculating cage with positive roller guidance between lipped raceways. Cage maintains uniform spacing of rollers, eliminating rubber friction; ends erratic performance at low speeds, caused by sliding, skewing and binding of rollers; and pulls unloaded rollers around bearing raceway. Approach ramp in roller path permits rollers to feed freely into the load zone. Suitable for vertical or horizontal linear reciprocating motion of machine elements or slides of precision machine tools. Bearing, 1¼ x 1⅛ x 3½ in., weighs 22 oz. Currently made to order; from stock in future. **Kaydon-Engineering Corp, Muskegon, Mich.**

Circle 310 on Reader Service Card

Reversible gearmotor . . .

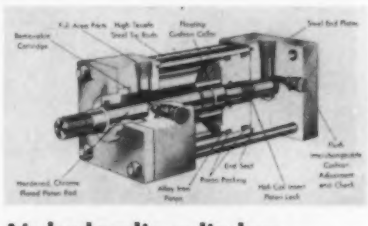
uses ball bearing-equipped motor and gearhead to provide instant reversing; output speeds from 0.3 to 500 rpm; low sound level; and torque up to 250 in.-lb at 10 rpm. Available in 1/15-hp, 220-v, 3-phase and 1/15-hp, 115-v, single-phase models. Gearhead has carbo-nitrided, special cut alloy steel generated gears and pinions which are said to assure extremely long life. All gear and pinion assemblies are copper-brazed for concentricity. **New England Gear Works Inc, South End Rd, Southington, Conn.**

Circle 311 on Reader Service Card

Compression spring filter . . .

is based on two interwound springs, one wire coiled around the other. This is said to allow precision spacing and spring-apart cleaning action with automatic return to original filter pattern. Available in three models for pressurized pipelines, suction tubes and immersion pumps, unit strains water-thin to high viscosity materials. Four available elements have filter action comparable to 20, 40, 60 and 100 mesh screens. Medium-pressure model handles line pressures of 1000 lb. Non-collapsible element performs at differential pressures exceeding 100 psi. **Chrom-O-Lite Co, 2701 E 78th St, Minneapolis.**

Circle 312 on Reader Service Card



Air-hydraulic cylinders . . .

are rated at 250-psi air and up to 2400-psi hydraulic. Have both cushion adjustment and ball check flush in cylinder end plates, saving space and eliminating clearance problems. Removable cartridges are self-contained units with compensating lip-type wiper seals, self-adjusting multiple-lip rod seals and extra long bronze bearings that provide max rod support when piston rods are extended. Available in 11 bore

continued on page 66

4 solutions to your special timing applications...

HANSEN SYNCHRON TIMING MOTORS

• **Versatile Hansen SYNCHRON Timing Motors** have *proved* more dependable in meeting impartial test requirements than competing motors. Such tests prove that Hansen SYNCHRON motors deliver peak operating efficiency continuously for as much as 1½ years, and longer.

Each of the 4 Hansen SYNCHRON Timing Motors shown here gives this kind of performance . . . and one could be the solution to your timing problem. Some of the wide variety of commercial and industrial applications include: timing machines; telemetering and transmission equipment; cam and valve switches; heating and air conditioning devices; recording thermometers; television cameras and equipment; and many others.

Self-starting and self-lubricating, these Hansen SYNCHRON Timing Motors operate efficiently in any position. They pull from 8 to 30 in./oz. guaranteed torque . . . at temperatures ranging from —40°F to +140°F and at speeds from 0.8 to 600 r.p.m., 0.8 to 120 r.p.h. . . . in clockwise or counterclockwise rotation. More than 200 types of output available.

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HANSEN MANUFACTURING COMPANY, INC.
PRINCETON, INDIANA

sizes from 1½ through 1¼ in., with 25 mounting styles and wide range of piston rod diameters. **S-P Mfg Corp, 30201 Aurora Rd, Cleveland 39.**

Circle 313 on Reader Service Card

Torque type locknut . . .

is one-piece, all-metal, reusable fastener for applications where there is severe vibration or heavy shock loading. Eliminates need for heavy auxiliary locking devices, such as cotter pins, washers, double nuts, etc. Lock is developed by deflecting top threads slightly out of their true helix. Starts freely on bolt until deflected threads are reached; then requires wrenching into final position. Nut locks in any position on bolt, provided a min of 1 to 1½ bolt threads protrude beyond top of nut. Available in wide range of sizes and materials. **MacLean-Fogg Lock Nut Co, 5535 N Wolcott Ave, Chicago 40.**

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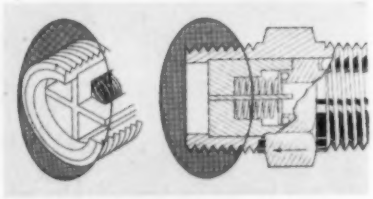


Disk-type check valve . . .

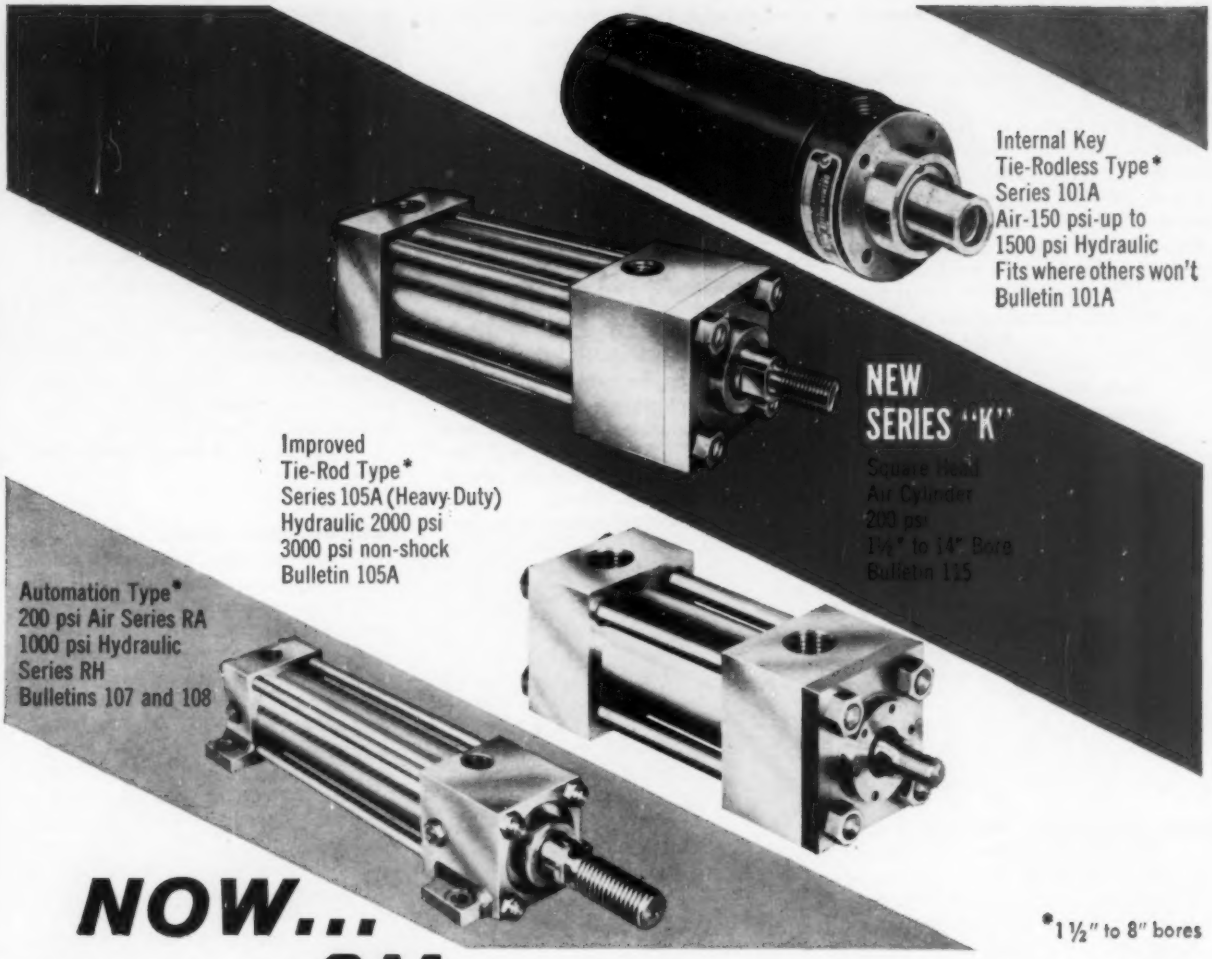
is housed in standard hex nipple and because of open type construction is said to have high flow characteristics. Opening pressure is 2 psi. Made of brass with Buna-N O-rings and stainless steel spring and disk. From stock in ¼-, ⅜- and ½-in. NPT sizes. Prices start at $3.50 for ¼-in. size. **Bodner & McDermott Mfg Co Inc, 19 Beechwood Ave, Mt Vernon, NY.**

Circle 315 on Reader Service Card

3-way brass miniature solenoid valve . . .

handles differential pressures from 0 to 200 psi or up to 500 psi for special applications. Available in normally-closed, normally-open, directional and free-venting versions. Small size, yet same flow capacity and working pressure ranges of larger conventional 3-way solenoid valves are made possible by improved flux path and heat dissipation. Weighing only 15 oz, complete valve is 3$\frac{13}{16}$ in. high over-all. Brass body is $\frac{7}{8}$ in. deep, 1$\frac{7}{16}$ in. dia. Body orifices of $\frac{3}{64}$, $\frac{1}{16}$, $\frac{3}{32}$, $\frac{1}{8}$ and $\frac{3}{16}$ in. dia have Cv factors of 0.05, 0.12, 0.21, 0.32 and 0.41, respectively; upper orifices of $\frac{1}{16}$ and $\frac{1}{32}$ in. dia have 0.08 and 0.12 Cv factors. Standard valve handles liquids and gases

continued on page 68



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from —45 to 150 F; special models from —60 to 350 F. Operate time, in any position, is 8 to 12 millisec. Burst pressure is rated at 6000 psi. Standard model is bubbletight; special models available for not over 1-micron leakage. Coil voltages are 6 to 440 v ac (50 to 60 cps); 6 to 220 v dc. Prices are said to be lower than larger solenoid valves of comparable performance. Also available are 2-way, normally-open and normally-closed versions. **Allied Control Co Inc, Valve Div, 2 East End Ave, New York 21.**

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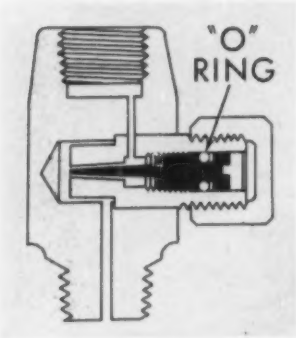

Gage pulsation damper . . .

is suitable for use on pumps, compressors and other pulsation-producing, air, gas or liquid-handling equipment within limit of 10,000-psi operating pressure. Said to effectively smooth out pulsation, reduce gage flutter, protect gage mechanisms from excessive wear or destruction and maintain calibration accuracy. Uses a variable orifice which permits full pressure measurement but prevents surge or shocks by throttling abrupt pressure changes of large or small amplitude. Variable orifice can be externally adjusted without disconnecting line or gage. Available in ¼- and ½-in. sizes. **Kunkle Valve Co, 121 S Clinton St, Ft Wayne, Ind.**

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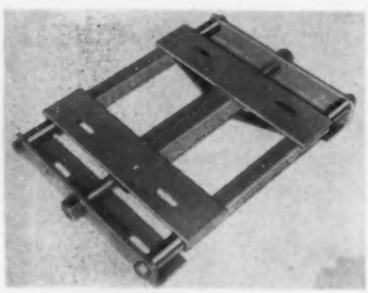


Motor mounts . . .

are all-welded, tension-controlling bases with freely movable carriages. Said to eliminate excessive wear on belts and bearings by automatically providing proper amount of belt tension even under heavy starting loads. Adjustment, when necessary, can be made while operating under load by turning a screw. No bolt or nut is disturbed and initial pulley alignment is maintained. Available in three series: Series 100 which has self-contained spring to control belt tension and compensate for belt stretch, supplied in standard and vertical types for 19 NEMA frame sizes from 56 through 326-U; series 200 for use with spring-loaded, variable-pitch pulleys in same NEMA frame sizes as 100 series; and series BB which accommodates larger motors and in which motor carriage rides on linear ball bearings that extend length of carriage. Latter series has two models—one for NEMA frame sizes 364 through 505 and other for sizes 364-U through 445-U. **Manheim Mfg & Belting Co, Manheim, Penna.**

Circle 318 on Reader Service Card

Plug valve . . .

is free-turning, two-way, full-flow, nonfreezing and non-galling unit that rotates 360°. A quarter turn of solid tee head, left or right, opens and closes valve. Comprises three cast brass parts—body, plug and combined nut and washer—Teflon seal rings and Buna-N O-rings. Said to provide bubble tight shutoff and leakproof service even after 50,000 or more cycles at 0 to 125-psi pressure. Temp range is up to 250 F (with Viton O-rings, up to 400 F). Available in ¾- through 2-in. sizes. **Hays Mfg Co, General Products Div, Erie, Penna.**

Circle 319 on Reader Service Card

Fancooled motors . . .

are totally enclosed, fractional hp units which are suitable for applications where dust or dirt is prevalent. Cooling is accomplished by an outboard fan directing an air stream over motor. Available in ratings from ⅛ to 1 hp in NEMA-56 frame size, units meet NEMA standards in capacitor-start and polyphase single-speed and split-phase single and two-speed designs. All are rated continuous duty, 55 C rise. **General Electric Co, Schenectady 5, NY.**

Circle 320 on Reader Service Card

Cam-action drawer handles . .

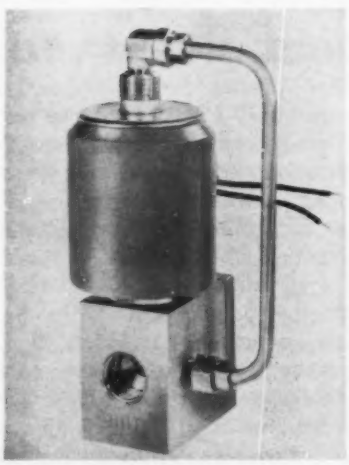
allow positive connector engagement and locking in racked electronic chassis. Each handle has recessed lever which cams last ¾-in. drawer travel with a mechanical advantage of 6:61. From stock at approx $18 per pair. **Jonathan Mfg Co, 720 E Walnut Ave, Fullerton, Calif.**

Circle 321 on Reader Service Card

Bellows seal valves . . .

handle rare and dangerous fluids at extreme temperatures and pressures. Units basically are forged stainless steel bodies with inert arc welded bellows assemblies and include gasketed construction, as well as completely welded valves. High-pressure version is rated for operation at 2000 psi and to temps of 600 F. Lower-pressure version is rated at 400 psi, up to 350 F and has replaceable Teflon seats and gaskets. Extra safety margin is provided by union bonnet construction combined with back seating and true secondary packing system. Each unit is helium leak-tested in production, with a max allowable leakage of only 0.0005 micron cu ft per hr. **Hoke Inc, 1 Tenakill Pk, Cresskill, NJ.**

Circle 322 on Reader Service Card



Two-way solenoid valve . . .

is for normally open operation (valve opens when solenoid is de-energized) at pressures to 500 psi. Supplied in ½-in. pipe size, with brass body, integral seat and Teflon disk. Handles air, water or light oil at temps to 212 F. Standard

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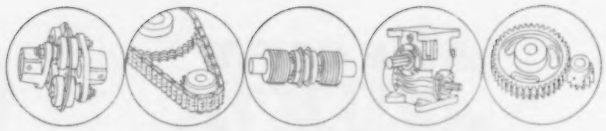

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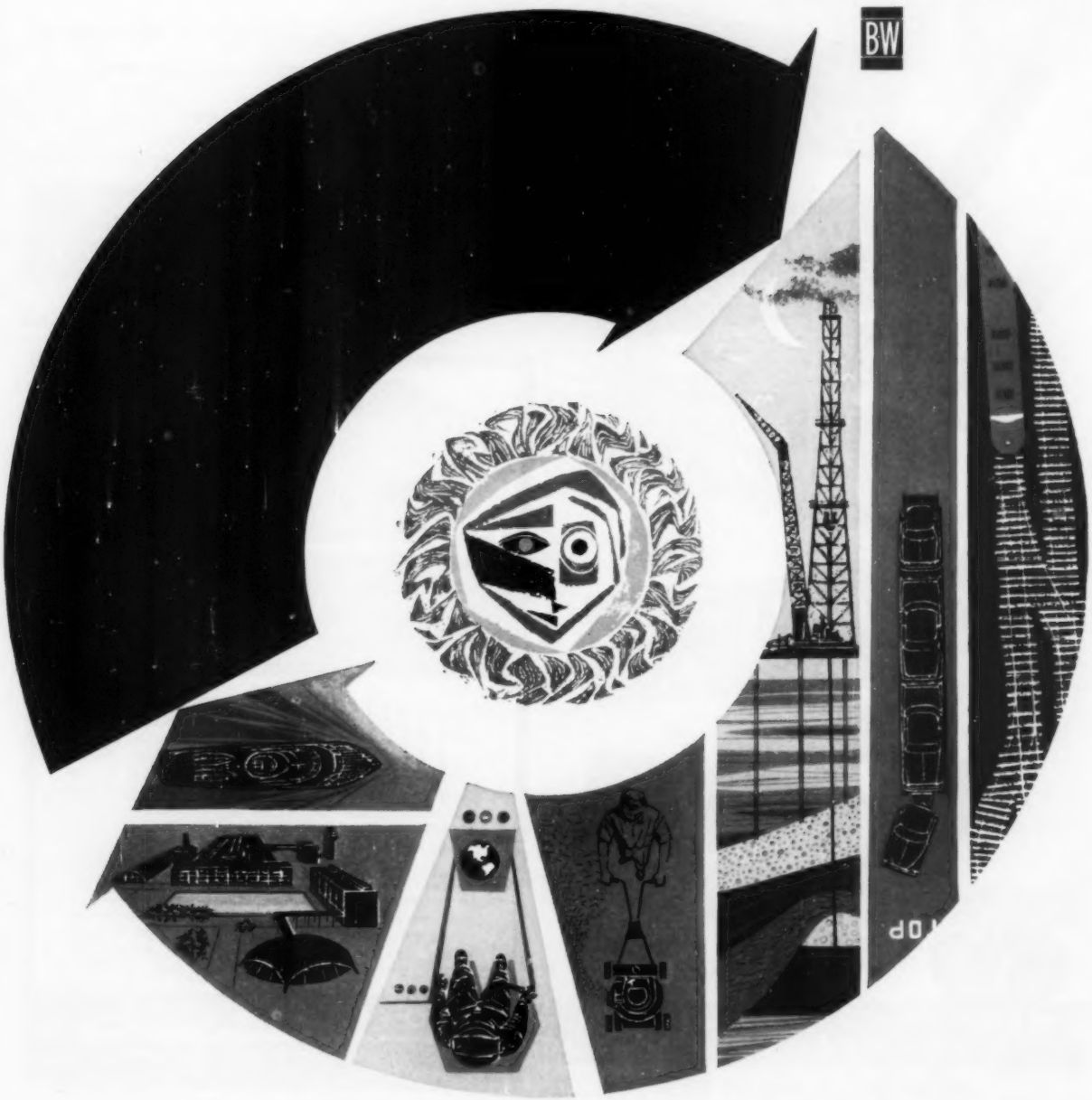

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The Model 601 Rotiform Torquemeter, with its infinitely adjustable range feature, permits observation of smaller torque increments at low torques and enables each sensor to cover a multitude of ranges. Over 200 interchangeable sensors are available with maximum torque ratings ranging from .015 oz-in to 6000 lb-in. The sensors detect torque at speeds to 65,000 rpm without physical contact with the rotating shaft. With factory calibration continuous display on the indicator is within 2% accuracy of selected full scale reading. Features include: simple compensation adjustment for ambient conditions and internal aging; sensor range changed at panel without calibration; sensor design permits either base-mounting or overhung end-mounting; solid state electronics.

ROTIFORM CO.

1509 Colorado Ave., Santa Monica, California

voltage is 115 v dc, 14.9 w, continuous duty. Priced at $100 in quantities of 1 to 5. Delivery in approx 8 wk. **Automatic Switch Co, Florham Park, NJ.**

Circle 323 on Reader Service Card

Stainless, aluminum handles

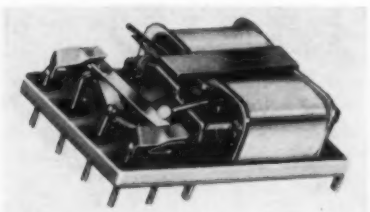
are available in 3-, 4- and 6-in. lengths and in either bright or non-reflective black finishes. Matching ferrules are included in line. All models are $\frac{7}{8}$-in. dia, have 1½-in. finger clearance and min thread depth of ¾ in. Ferrules are $\frac{9}{16}$ in. dia and $\frac{5}{16}$ in. high. Available after Aug 1, with prices starting at $.86 each for the pull handles and $.15 each for the ferrules. **Raytheon Co, Industrial Components Div, 55 Chapel St, Newton 58, Mass.**

Circle 324 on Reader Service Card

Liquid neoprene coating . . .

dries in minutes, forming a continuous rubber film on metal, wood, plastic, concrete and other surfaces. Coating is impervious to fresh and salt water, oils, gasoline, naphtha, acids, alkalies and other chemicals. Reportedly will not peel, blister or crack under changing climatic conditions. Available in pt, qt, 1-gal., 5-gal cans and in 55-gal. drums. Has shelf life of more than 1 yr when stored in sealed container. **Adhesive Products Corp, 1660 Boone Ave, New York 60.**

Circle 325 on Reader Service Card



Low profile relay . . .

has seated height of only 0.45 in., making it suitable for printed circuit board applications. Low profile is achieved by positioning header 90° to a side mounting configuration. Micro-miniature unit also has plug-in terminal design, with both connector pins and mounting posts extending through component board. Performance features include: dry circuit current requirements of 1 microamp at 1 mv with 100 ohm max contact resistance; 3-amp contact rating at 32 v dc resistive load; and 5 millisec max operate/release time. Life tests at full load and 257 F have exceeded 100,000 operations. Priced at approx $14 in small quantities, with delivery in 2 to 3 wk. **Babcock Relays, Div of Babcock Electronics Corp, 1645 Babcock Ave, Costa Mesa, Calif.**

Circle 326 on Reader Service Card

Strain-gage pressure transducer . . .

measuring 2¾ in. dia x 2⅝ in. long, is for high-line, low-differential service. Has line pressure rating of 5000 lb with less than 1% full range shift from zero to 5000 psi and withstands 8000 psi without damage. Differential pressure range is from ±15 psid to ±100 psid. Reportedly will not deviate from specifications after application of differential pressure up to 10 times rated pressure. Combined effects of linearity and hysteresis do not exceed ±0.75% of full range output as measured from best straight line through calibration points. Has operable temp range from —70 to 300 F; compensated temp range from —65 to 250 F; and thermal sensitivity and zero shift within 0.01% FR/°F over compensated temp range. Both active and reference pressure ports tolerate fluids compatible with type 347 stainless steel. **Consolidated Electrodynamics Corp, 360 Sierra Madre Villa, Pasadena, Calif.**

Circle 327 on Reader Service Card

Reluctance synchronous motor

is 3-in.-dia, 2P unit of open end-ventilated construction. Uses Class B material for stator core insulation to ground and an epoxy "blue gray" varnish treatment for windings and shell finish. Continuous duty ratings are from 15 to 35 millihp in synchronous and through $\frac{1}{75}$ hp in split-phase, 2P designs. Ratings through $\frac{1}{20}$ hp are available in 4P, permanent-split capacitor designs. **General Electric Co, Schenectady 5, NY.**

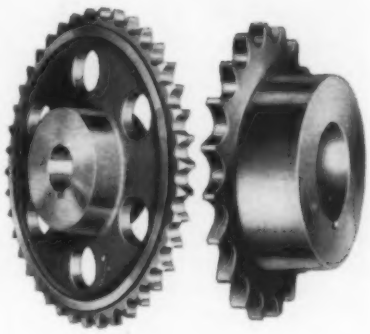
Circle 328 on Reader Service Card

Dry-film bonded lubricant . . .

has useful temp range of from —300 to 1200 F. Said to have proven effective under wide range of severe environmental conditions, including 50-hr operation on a thrust ball bearing at 840 F and on a ball bearing operating at 3500 rpm at room temp for 1000 hr. Starting torque at —100 F is 12.5 in.-lb, compared with 126 in.-lb for conventional —100 F grease.

continued on page 73

A Morse answer



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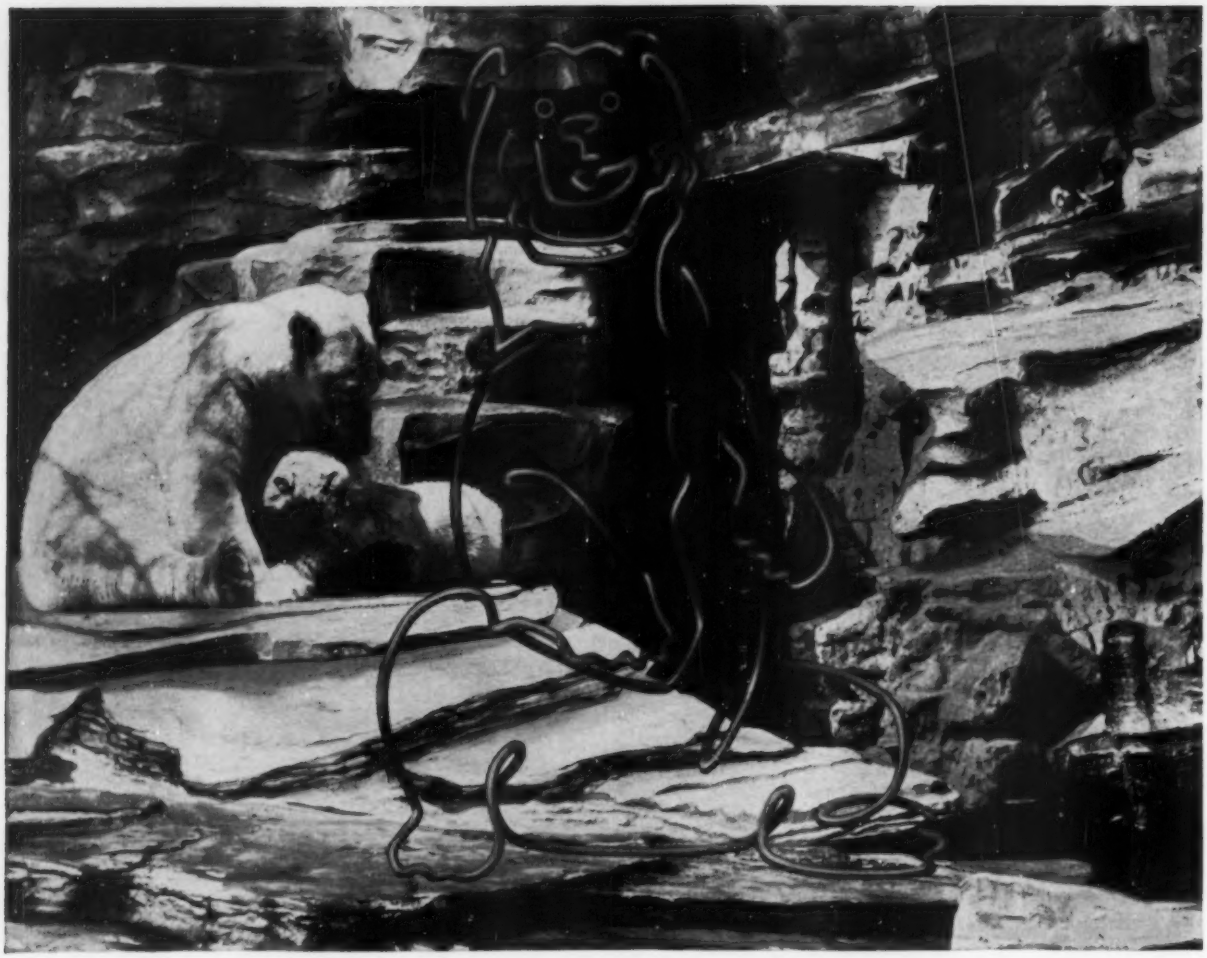
Morse Chain Co., Dept. 4-71, Ithaca, N.Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.



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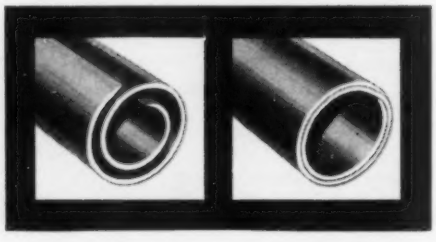
* * *



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provides pot life of about 15 min. at room temp to pour void-free objects of large dimensions. Viscosity at that temp is 20/25 poises. System is two component, comprising a polyol and prepolymer. Inhibiting principle controls usually fast reaction rate when prepolymer is added to filled polyol. When cured (24 hr at 80 F or 1 hr at 200 F) material has dielectric strength of 450 v/mil, high tensile strength, resilience, and high resistance to tear, abrasion and compression set, oils, solvents, oxidation, ozone and low temps. Available in qt-, gal.- 5-gal and 55-gal containers. **Poly Resins, 11655 Wicks St, Sun Valley, Calif.**

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with separate sound and inaudible signal channels, actuates relays automatically. Instrument is basically a tape recorder with an electronic timing unit which enables it to operate cycled motion-type equipment such as slide projectors, animated displays, etc. with or without sound. Inaudible signal can be recorded and erased to suit required cycling. Equipped with continuous tape magazine and graphited Mylar tape. Operates on 115/120 v ac, has built-in speaker and provisions to drive remote speaker and/or audio amplifier. Contained in metal case with overall dimensions of 6 x 8 x 8 in. Four models available. **Tecni-Art Engineering, PO Box 96, Glendale 5, Calif.**

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How linkages and springs may be designed to balance loads, transmit forces, feed parts, 24 p.

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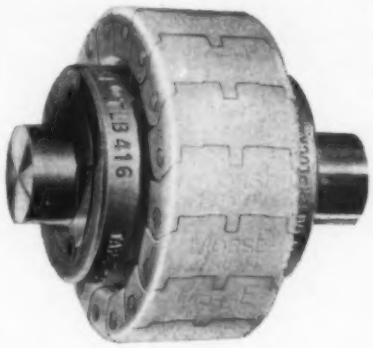
How to design for reliability, human factors, statistical tools; implementing the programs, 32 p.

A Morse answer



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DESIGN LITERATURE

Advanced Structural Analysis

S F BORG and J J GENNARO. D Van Nostrand Company, Inc, 120 Alexander St, Princeton, NJ. 6 x 9, 368 pp. $7.50.

This book presents comprehensive analysis of structural theory and its applications. Starting with basic classical concepts, the authors develop the most recent methods, including the principles of slab and shell analysis, temperature analysis, torsion, and numerical methods. A chapter examines a new field of rapidly increasing importance: the use of electronic computers to solve structural problems.

The first four chapters present a detailed discussion of the various methods for determining deflections and for solving statically indeterminate structures. The authors then explore advanced topics of greatest interest today, including the theory of arches and deflection theory, numerical and approximate methods of analysis, torsion analysis, limit design, and temperature analysis. The relation between the so-called exact methods and the various approximate methods is analyzed.

Mechanization of Motion

LEE HARRISBERGER, assoc. prof of mechanical engineering, N Carolina State College. John Wiley & Sons, 440 Park Avenue South, New York 16. 6¼ x 9¼, 363 pp. $8.50.

Here is a book primarily intended to present rational procedures for the synthesis of mechanisms. It combines the fundamentals of kinematics, the techniques of ideation, and new techniques of analysis. This combination is presented as a step-by-step discussion of logical procedures for synthesizing mechanical systems in order to satisfy any motion requirement.

An Introduction to Transportation Engineering

WILLIAM W HAY, prof. of railway civil engineering, U of Illinois. John Wiley & Sons, 440 Park Avenue South, New York 16. 6 x 9, 505 pp. $11.75.

The book covers that area of transportation information that lies between structural design and engineering on one hand and the economic aspects of various transportation means on the other. The subject matter of this intermediate area is the effects of technological factors on movement and the principles involved. A unified approach to the problem is achieved by cutting across the conventional boundaries that separate railways, highways, airways, etc into unrelated problems. This demonstrates the common core of problems and principles present in all transport systems.

Finite Difference Equations

H LEVY AND F LESSMAN. Macmillan Co, 60 Fifth Ave, NY 11. 5½ x 8½, 278 pp. $5.50.

The calculus of differences is of particular interest today because it is a numerical method for solving troublesome differential equations on digital computers. This book is an introduction in which the authors stress problem solving rather than pure mathematics. They begin with a review of elementary difference operations, interpolation and extrapolation. From this they move to difference equations, those with constant coefficients, those with variable coefficients and those associated with functions of two variables.

A chapter on applications shows how the difference equation is applied to problems of dynamics, bending of beams and vibration. Sample exercises are scattered throughout the text and answers given in the appendix. The British notation and terminology, which is used throughout, will not give difficulty unless the book is used as a classroom text.

Other Books of Interest

Leadership and Organization: A Behavioral Science Approach

R Tannenbaum, I R Weschler, F Massarik. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 6¼ x 9¼, 456 pp. $7.50.

Discusses most of the psychological concepts involved in leading and managing formally organized groups, such as engineering staffs.

Management Guide for Work Simplification

B T Lewis, W W Pearson. John F Rider Publisher Inc, 116 W 14th St, NY 11. 5½ x 8½, 80 pp. $1.50.

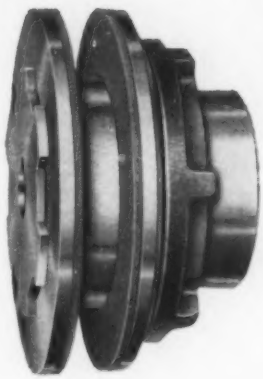
Reflections on the Motive Power of Fire

Sadi Carnot. Dover Publications Inc, 180 Varick St, NY 14. 5¼ x 8, 152 pp. $1.50.

A paperback edition of Carnot's classic work on thermodynamics.

continued on page 78

A Morse answer



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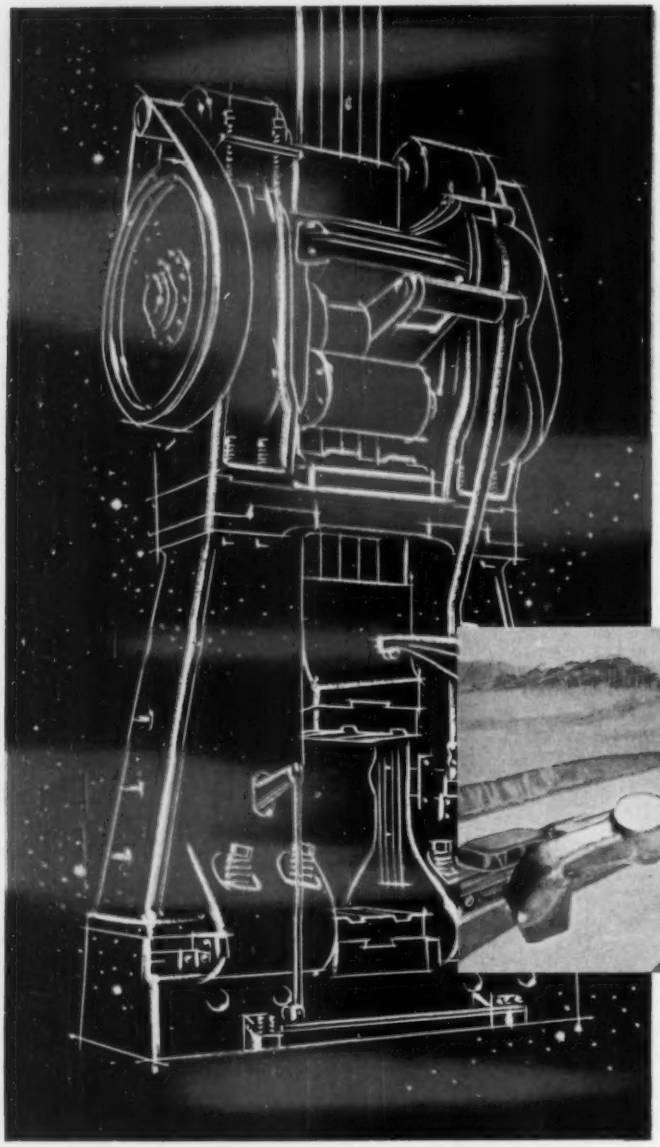
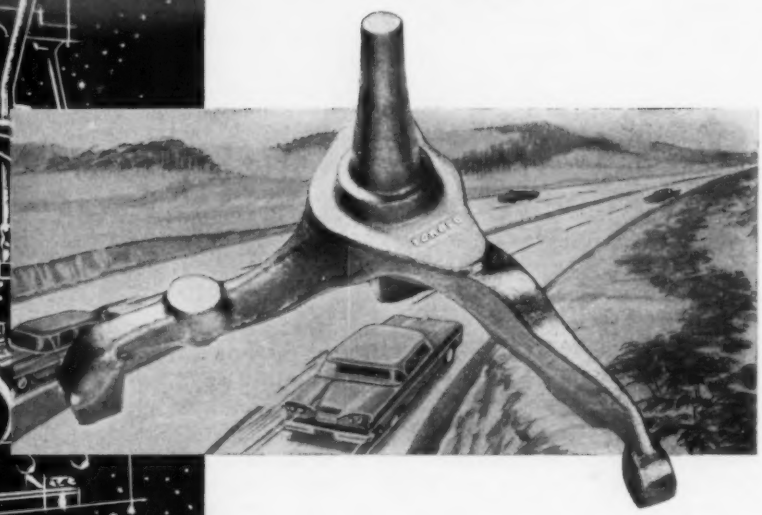


SHOCK-STRENGTH of steering spindle soars by designing it to be forged



Modern board-lift forging hammer

By designing front-end spindles to be forged, automobile and truck manufacturers practically eliminate danger of failure of these vital parts, even under sudden turning stress that can reach thousands of foot-pounds.

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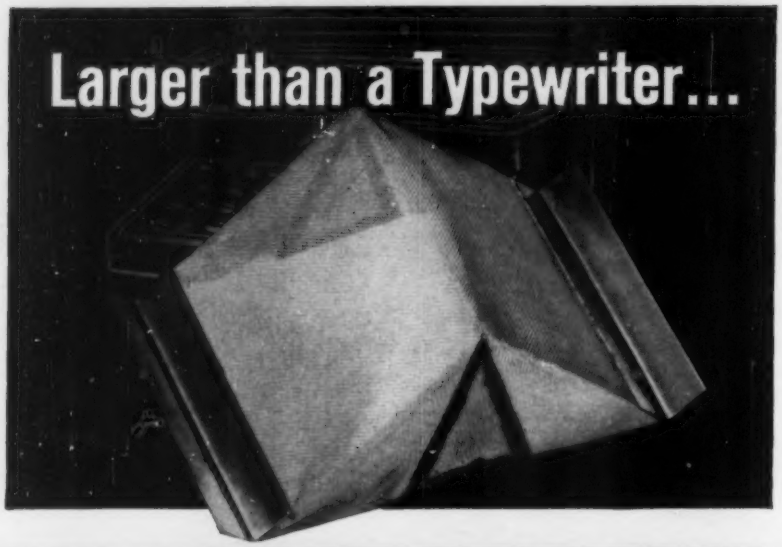

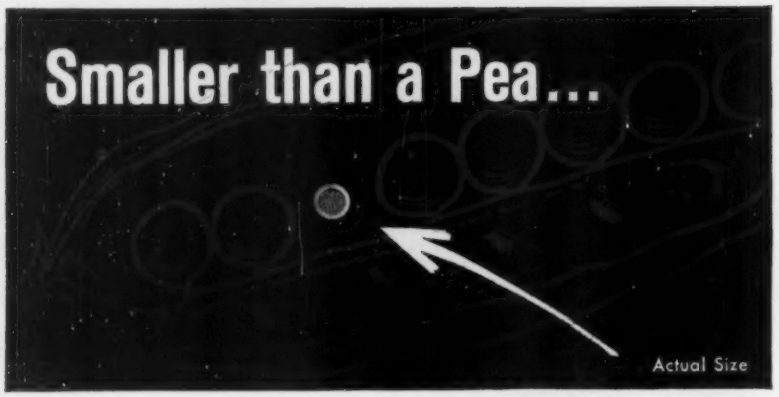

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Alfred DelVecchio. Philosophical Library Inc, 15 E 40th St, NY 16. 6¼ x 9½, 346 pp. $6.

Modern Flight Dynamics

W Richard Kolk. Prentice-Hall Inc, Englewood Cliffs, NJ. 6¼ x 9¼, 288 pp. $10.

ABSTRACTS FROM THE LITERATURE

High Temperature Corrusion

The paper is concerned with the corrosion phenomena likely to influence the selection of materials for refinery service at elevated temperatures. The problems of oxidation, sulfidation and carburization are discussed in detail and consideration is given to the effects of condensate corrosion and residual oil ash corrosion. The contributions of various alloying elements in the common engineering alloys to their physical and mechanical behavior as well as to their corrosion resistance at elevated temperatures are discussed. Basic considerations for the selection of suitable alloys to withstand h' ;h temperature corrosive environments are outlined.

"High Temperature Corrosion in Refinery and Petrochemical Service," by E. N. Skinner, J. F. Mason and J. J. Moran, Corrosion, Dec 1960. National Assn of Corrosion Engineers, 1061 M & M Bldg, Houston 2, Texas.

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It is important for all engineers to understand potable water problems and to appreciate the various alternative solutions. By 1980 the predicted demand for fresh water (597 billion gpd) will exceed the dependable available natural waters (515 billion gpd). If our economy is not to falter, saline-water conversion will have to receive increased attention. Methods are: The long-tube vertical type of evaporator, multistage flash distillation, electrodialysis, forced-circulation vapor compression, and freezing.

"Fresh Water from Salt Water," by Allen Cywin, U. S. Dept. of the Interior, Washington, D. C., Mechanical Engineering, Oct 1960, American Society of Mechanical Engineers, 29 W 39th St, NY 18.

Grade Markings for Bolts

Grade markings on bolt heads identify material, strength and the specifying group or user. These markings

continued on page 83

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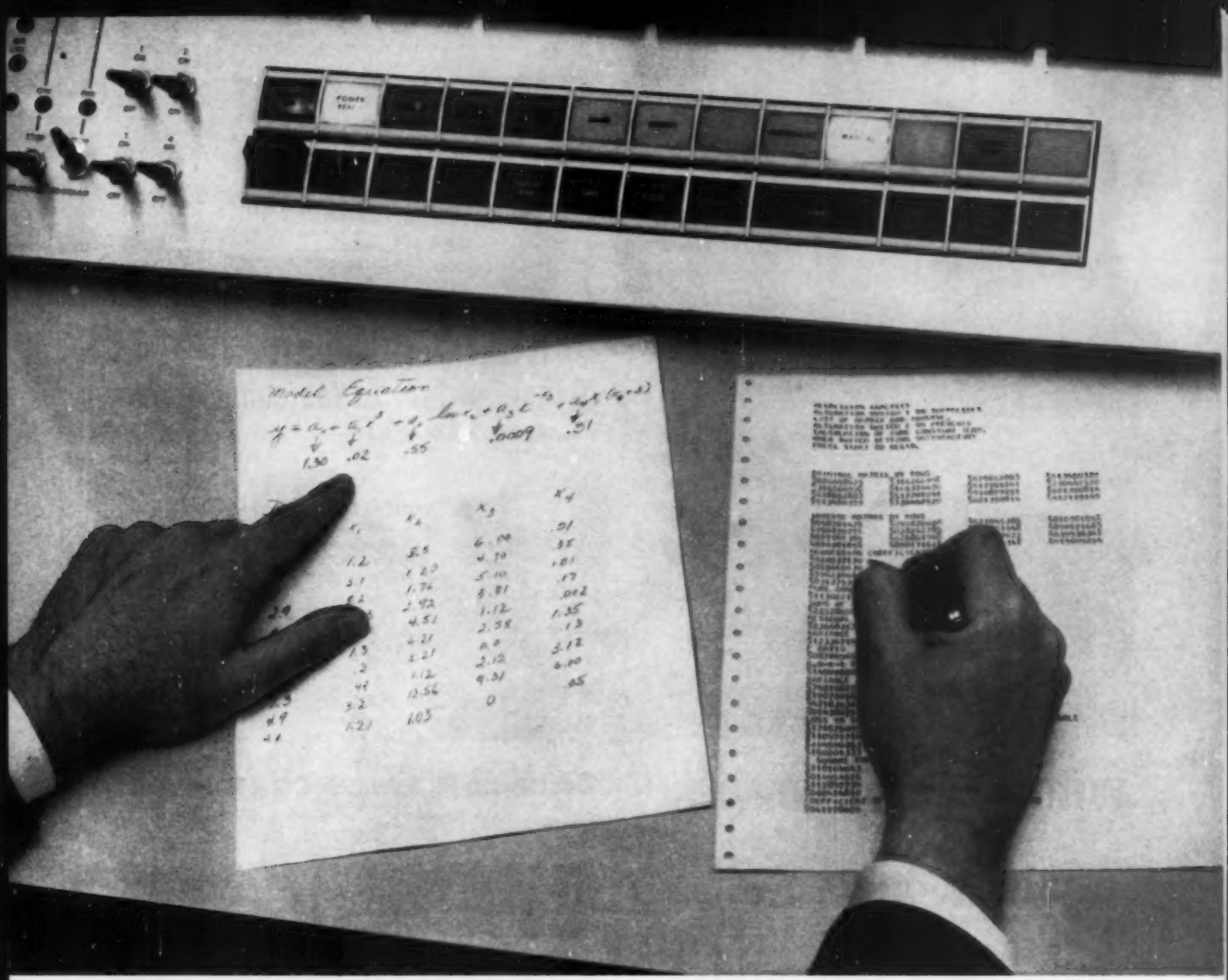

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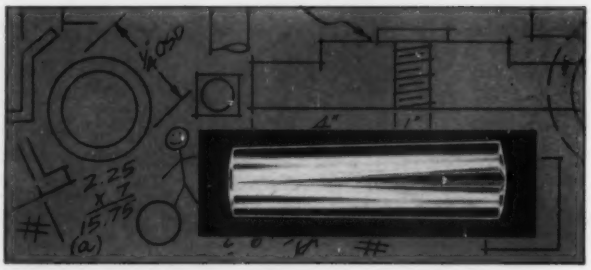

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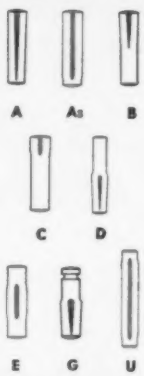

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serve as a quick visual check of the product upon receipt. They also aid the assembly operator to install the correct grade of fastener.

"Grade Markings for Bolts," by Frank W. Wook Jr, Advanced Designs Inc, Vienna, Va. American Machinist Metalworking Manufacturing, Apr 3, 1961, 330 W 42nd St, NY 36.

Water Content of Compressed Air

Water content and dew point of compressed air can be important considerations in design of air systems. This nomogram is handy for finding the usual quantities required for design purposes.

"Calculate Dew Point and Water Content of Compressed Air," by F. Caplan, Oakland, Calif, Power, July 1960, 330 W 42nd St, NY 36.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

SPEED REDUCERS—Bulletin J-25, 32 pp. Cites advantages of spiral bevel speed reducers and covers basic types, special features of vertical types, applications, selection procedure, overhung and thrust load capacities, standard assemblies, hp and thermal ratings, general dimensions, backstop selection and bedplate dimensions. Hewitt-Robins, Dept SR, Stamford, Conn.

Circle 350 on Reader Service Card

PRECISION SPRINGS—Handbook, 16 pp. Illustrates and discusses features of all types from simple compression, extension and torsion springs to Belleville, wave and finger-type washers. Both round and flat wire forms and non-ferrous specialties are also covered. Design formulas are explained, while tables and curves supply other data for determining spring needs. Timms Spring Co, Elyria, Ohio.

Circle 351 on Reader Service Card

MAGNETIC PLUGS, CHIP DETECTORS—Catalog MPC-61, 26 pp. Lists specifications and applications for magnetic plugs, special magnetic assemblies, chip detectors, self-closing valves and pipe plugs. Discusses and illustrates how and where to use magnetic plugs to prevent wear caused by ferrous particles in a lubricant or hydraulic fluid. Lisle Corp, Clarinda, Ia.

Circle 352 on Reader Service Card

WORM GEAR SCREW JACKS—Catalog, 28 pp. Describes 2-, 5-, 10-, 15-, and 25-ton capacity models for leveling, ad-

continued on page 85

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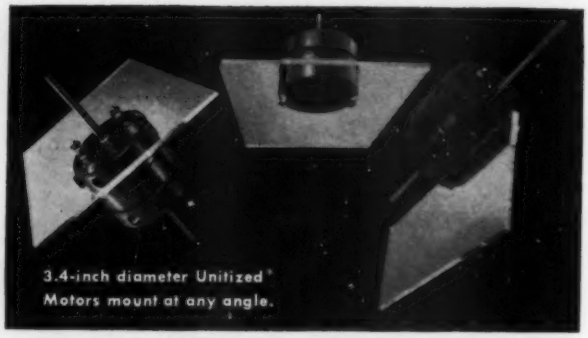

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justing and stabilizing machinery and equipment, and offers typical drive arrangements, dimension drawings and specifications on speeds, loading and hp/torque requirements. Includes design tips for OEM market. Joyce-Cridland Co, Customer Service Dept, 2027 E First St, Dayton 3, Ohio.

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TEMPERATURE REGULATORS – Catalog TCV-1, 8 pp. Contains cutaway drawings, features, ratings, dimensions, applications, ranges, materials of construction, flow curve, sizing charts, etc., covering models from ¼- through 6-in. sizes. OPW-Jordan, 6013 Wiehe Rd, Cincinnati 13.

Circle 354 on Reader Service Card

DUCTED-PROPELLER FANS–Catalog E-2800, 4 pp. Reviews performance features, available versions, materials and finish, capacity and prices. Includes capacity and noise level curves, as well as dimension drawings. Rotron Mfg Co Inc, Woodstock, NY.

Circle 355 on Reader Service Card

METALLIZED OVERLAYS–Data sheet T-3, 2 pp. Discusses selection of metal powders for sprayed overlays and two methods of applying them. Table compares values of five different hard-surfacing powders. Wall Colmonoy Corp, 19345 John R St, Detroit 3.

Circle 356 on Reader Service Card

IMPREGNATED COMPRESSED PAPER PULPS–Brochure, 4 pp. Discusses production of the plastic and paperboard; its advantages, limitations and economies in molded product design; type of finished

continued on page 87

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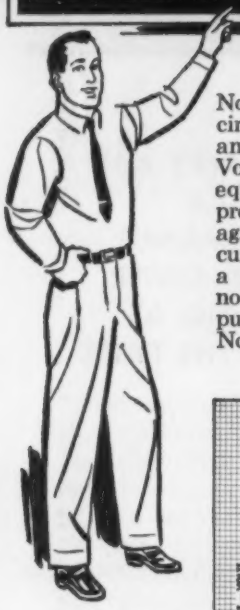

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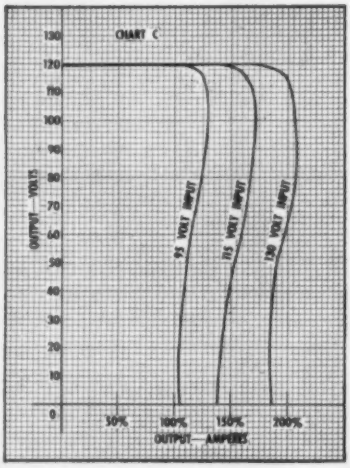

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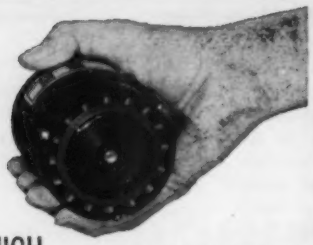

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surfaces; properties; characteristics; and how and where to use the material. Roforms, 71 Elm St, Cincinnati 2.

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SMALL INDUCTION MOTORS—Bulletin GEA-7300, 6 pp. Contains performance curves, rating charts and tabulated dimensions of three frame sizes (3- $3\frac{7}{8}$- and $4\frac{7}{8}$-in. dia) rated from 0.015 to $\frac{1}{4}$ hp. Cutaway photo shows internal operating features. General Electric Co, Schenectady 5, NY.

Circle 358 on Reader Service Card

INSTRUMENTS AND CONTROLS—Bulletin G14-1, 4 pp. Illustrates and reviews specifications of fluid meters for recording, indicating and integrating; transmitters and recorders for pressure and draft; level transmitters; and temperature instruments. Bailey Meter Co, 1050 Ivanhoe Rd, Cleveland 10.

Circle 359 on Reader Service Card

HIGH-SPEED MAGNETIC COUNTER—Bulletin, 4 pp. Lists applications for the electrically-actuated reset counter, discusses timing of contact coordinates and supplies specifications and engineering drawings. Veeder-Root Inc, 70 Sargeant St, Hartford 2, Conn.

Circle 360 on Reader Service Card

LIGHTWEIGHT ABLATION MATERIAL—Bulletin 8.1, 2 pp. Lists physical, mechanical and thermal property values of reinforced plastic which combines ablation resistance with thermal insulation and heat resistance, and which is 25% lighter than similar materials. Also traces characteristics and available forms. Taylor Fibre Co, Norristown, Penna.

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continued on page 88

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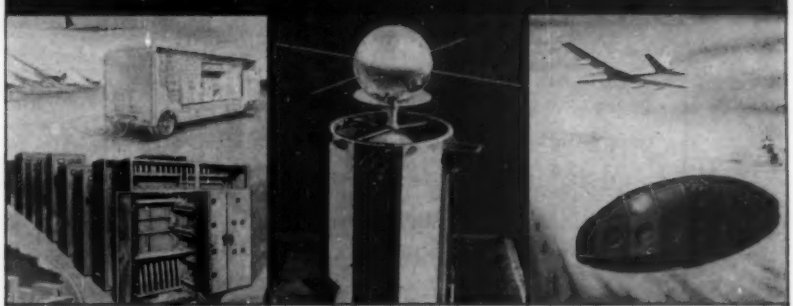

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PRESSURE MEASURING INSTRUMENT—Brochure, 4 pp. Spells out design features and ratings of instrument which can be used as a low pressure deadweight gage or high-range differential pressure monometer. ToPaz Inc, 2525 South Blvd, Houston 6, Tex.

Circle 362 on Reader Service Card

CONTROLS AND TORQUE SYNCHROS—Data sheet CS/TS-4-11-1, 4 pp. Tabulates more than 25 typical characteristics of transformers, transmitters, differential transmitters and receiver transmitters. Schematics show body terminal block, spline and dimension data. Wiring diagrams and terminal designations are included. Vernitron Corp, 125 Old Country Rd, Carle Place, LI, NY.

Circle 363 on Reader Service Card

HI-TEMP SWITCHES—Folder 84-449, 4 pp. Illustrates and reviews specifications of 10 switch types which provide snap-action switching in both high and low temp extremes. Micro Switch Div, Minneapolis-Honeywell Regulator Co, Freeport, Ill.

Circle 364 on Reader Service Card

INDICATOR LIGHTS—Data sheet 6105, 2 pp. Covers both heavy duty and miniature units for oil-water-dust proof applications. Contains specifications, dimension drawings and lists of available lenses and suitable lamps. Drake Mfg Co, 4626 N. Olcott Ave, Chicago 31.

Circle 365 on Reader Service Card

SPECIAL APPLICATION PUMPS—Bulletin 150.6, 4 pp. Tabulates ratings and dimensions of 16 sizes of a "progressing cavity" pump with capacities to 3000 gph and pressures to 350 psig. Dimension drawings are included. Customer Service Dept, Moyno Pump Div, Robbins & Myers Inc, Springfield, Ohio.

Circle 366 on Reader Service Card

HYDRAULIC CONTROL PILOT—Bulletin HCP-61, 2 pp. Discusses operation and applications for spring-loaded, diaphragm-actuated pilot for diaphragm valves. Includes table of arrangements and parts and materials list. Atlas Valve Co, 280 South St, Newark 5, NJ.

Circle 367 on Reader Service Card

PLUGS AND JACKS—Catalog 70, 16 pp. Contains detailed specifications and line drawings of 35 basic types of the miniature connectors designed for space-saving patchwork on panel boards. Mating parts are tabulated. Cambridge Thermionic Corp, 445 Concord Ave, Cambridge 38, Mass.

Circle 368 on Reader Service Card

CAST ALLOY—Booklet 6102, 12 pp. Covers advantages of cast alloy for cutting

tool and wear applications. Supplies properties, solubility, performance data and cutting speed range of material, comprised chiefly of cobalt, chromium, tungsten, columbium and carbon. Explains how to braze and grind it and how to use it in combination with carbide or high speed steel. Vascoloy-Ramet Corp, Waukegan, Ill.

Circle 369 on Reader Service Card

PUSHBUTTONS—Bulletin GEA-7127A, 12 pp. Carries ratings and performance data on miniature, oil-tight pushbuttons and cutaway photos depicting such features as pressure-type terminals, double-break contacts and multiple oil seals. Individual photos show each type of operator and accompanying table lists forms and colors available. General Electric Co, Schenectady 5, NY.

Circle 370 on Reader Service Card

BERYLLIUM COPPER STRIP—Bulletin, 4 pp. Outlines mechanical properties for each of six available tempers and recommended min radii for 90° bends. Thermal stress relief, forming and joining procedures are described, with instructions for pickling and plating. Brush Beryllium Co, 5209 Euclid Ave, Cleveland 3.

Circle 371 on Reader Service Card

STEEL DESIGN AND ENGINEERING—Brochure, 59 pp. Four papers discuss advances in strength levels, product forms and design applications of constructional steels, and how these advancements affect design practice and economy. Actual designs and design concepts are described and illustrated. Market Development Div, US Steel Corp, 525 William Penn Pl, Pittsburgh 30.

Circle 372 on Reader Service Card

AIR-OPERATED DIAPHRAGM VALVES—Bulletin 134-A, 6 pp. Covers eight types of air operators for valves from ¼- through 12-in. sizes, providing sectional drawings, line pressure curves, dimensional data, etc. Also describes and illustrates travel stops for limiting valve closure, limits stops for limiting valve openings and positioning devices for throttling service. Hills-McCanna Co, 400 Maple Ave, Carpentersville, Ill.

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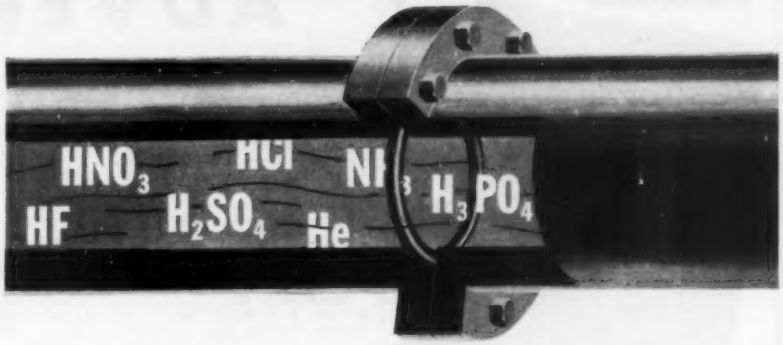

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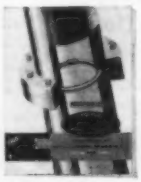

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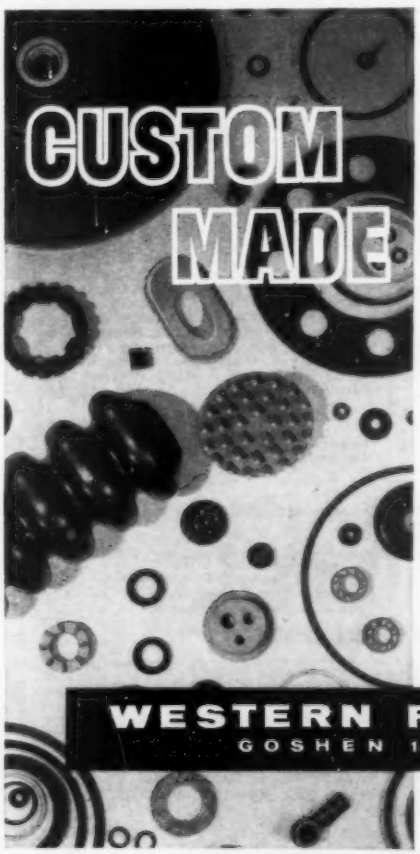

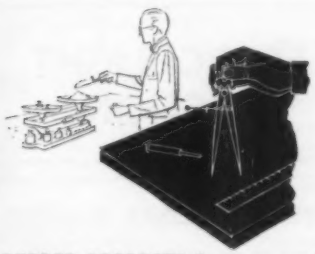

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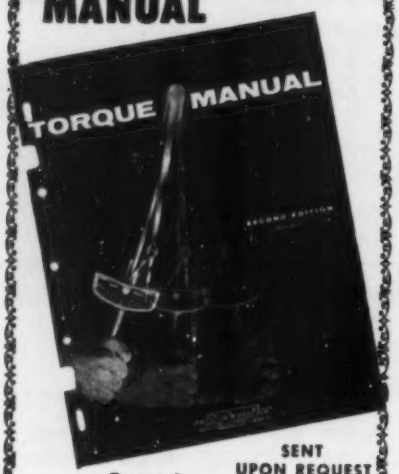

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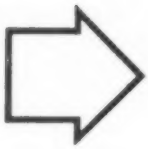

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Some are lever-and-spring systems, others are buckled columns, but all offer better isolation of shock and vibration.

596—WHICH INSTRUMENT MOTOR?

Your choice is based on these selection factors: starting torque, response time, speed and speed range.

597—THE YO-YO DESPINNER STOPS ROTATING MASSES

Two small masses unwind from a spinning body and stops it in a fraction of a second.

598—STANDARDS FOR PRINTED WIRING BOARDS

Five different military standards are boiled down to a guide for industrial service.

599—THE RIGHT INSULATION

A simple method based on two large tables, helps find the best one for your application.

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Load and speed characteristics and a simplified 10-step design procedure.

602—WHICH SHOCK-ABSORBING SYSTEM?

A comparison table plus a few quick calculations with these efficiency factors will help choose the best for your design.

603—HOW TO SELECT A FLOWMETER

Roundup of available types and simplified selection procedure.

604—DEVELOPMENTS IN LUBRICATION

A wealth of new equations, design charts and performance data from this year's ASLE meeting.

605—FIBERGLASS-REINFORCED THERMOPLASTICS

They are closing the performance gap between thermoplastics and metals.

606—THREADED INSERTS

Types available, factors governing selection, strength and cost characteristics.

607—SYNCHRONIC INDEX OF GEAR TRAINS

Method finds turns of input before gear positions repeat.

608—HOW TO LISTEN—AND REMEMBER

Here's what the psychologists say will improve your "listening power."

609—DON'T OVERLOOK ELECTROFORMING

It needn't be costly with these new mandrel systems, plating alloys and design methods.

610—SOLDERED ELECTRICAL CONNECTIONS

A complete design procedure covering all types.

611—WHICH CLUTCH?

Three-step procedure pinpoints type, location and size.

612—VALUE IN DESIGN

Present and future potentialities of specialist services in design engineering.

613—FAILURE ANALYSIS

Where and how to look for the trouble in new miniaturized designs.

614—TOMORROW'S POWER SOURCES

14 mobile power sources to generate from 1 to 500 hp.

615—NEW GEAR CLASSIFICATION

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616—UNCONVENTIONAL POWER SOURCES

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617—METAL FINISHES

From paints to bonded lubes—what they can do, how they compare.

THIS WEALTH OF VITAL INFORMATION . . .

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306—Neoprene-asbestos Gasket Material
308—Stainless Steel Spring Wire
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323—Two-way Solenoid Valve
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316—3-way Brass Miniature Solenoid
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363—Controls and Torque Synchros, 4 pp, Vernitron Corp
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370—Pushbuttons, 12 pp, General Electric Co

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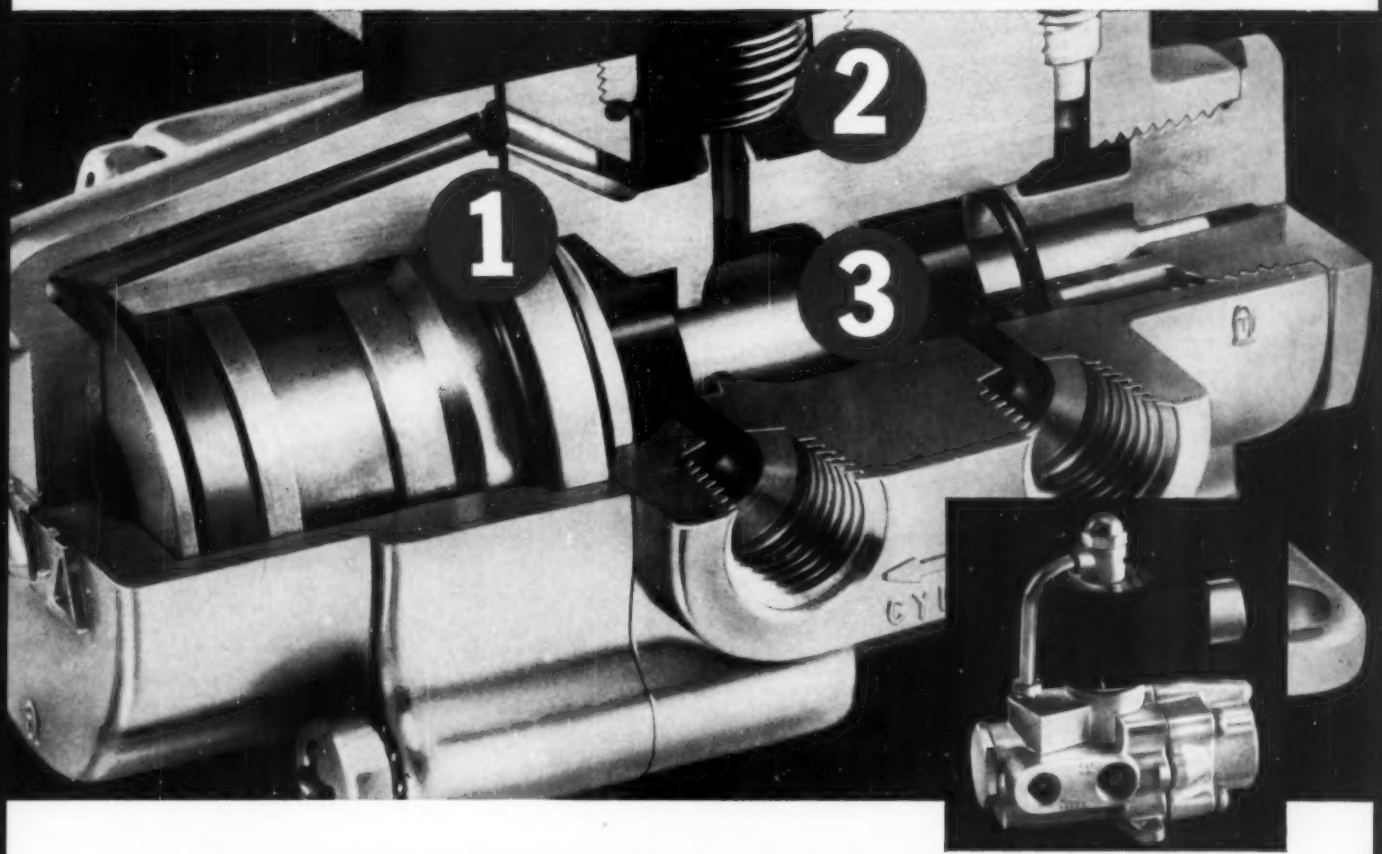
this is the way a valve is built to last

MILLIONS OF OPERATIONS:



NEW LOW-COST ASCO 4-WAY SOLENOID VALVES HAVE BEEN CYCLED MILLIONS OF OPERATIONS WITHOUT FAILURE

1. **TIGHT SEATING** with unique patented poppet-type seats—Patent Nos. 2,624,585—2,775,982
2. **RELIABLE OPERATION ASSURED**—failure to return due to residual magnetism is eliminated
3. **POWER OPERATION IN BOTH DIRECTIONS**—main valve not dependent upon return springs

Installation is simplified; the 8344 may be mounted in any position!

Poppet seals and a unique combination of metal-to-metal with resilient seating enable these and other ASCO 4-way solenoid valves to provide dead-tight shut-off, even on air, without lapping, grinding or close adjustments. The utter simplicity of design, eliminating return springs and power-operating the main valve in both directions, assures unprecedentedly reliable performance without maintenance for indefinite periods.

The new ASCO Bulletin 8344 valve is the latest embodiment of over half a century's design and development experience. Its low cost makes it economical even as a 3-way valve, with one pipe connection plugged.

Here are the pertinent statistics:

Pipe Size	Catalog No.	Solenoid Enclosures	List Prices†	Operating Information
¼"	83440	Std.	$48.00	Pressures: to 250 psi.
¼"	83444	Expl. proof	56.00	Temp: to 212°F.
⅜"	83441	Std.	48.00	Fluids: air, water, hydraulic oil
⅜"	83445	Expl. proof	56.00	

† Subject to trade and quantity discounts.

Other ASCO 4-way valves come in pipe sizes from ¼" to 1½" for pressures to 500 p.s.i. For complete information write for Catalog 202, and see the hundreds of types of 2, 3, and 4-way solenoid valves available for immediate delivery from the world's largest stock.

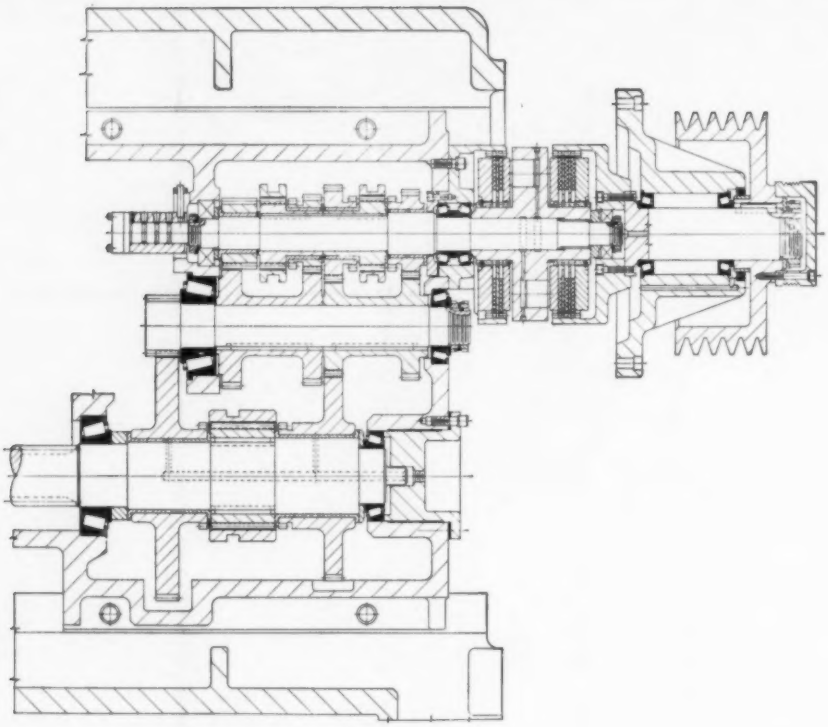
ASCO Valves

ASCO

DEPENDABLE CONTROL BY Automatic Switch Co. 546 HANOVER RD., FLORHAM PARK, N. J. • FRONTIER 7-4600 • AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

CIRCLE 202 ON READER SERVICE CARD

Bullard fully powered vertical turret lathe uses Timken® bearings to maximize production



When designing their Dynatrol® Vertical Turret Lathe, Bullard engineers' aim was to increase machine speed and output economically. Dynatrol provides single lever or remote control of all head motions, traverse and feed engagement. And Timken® tapered roller bearings at vital points—table radial position, headstock, clutch shaft, input pulley, rail raising bracket—provide the load-carrying capacity under varying loads and speeds that assures maximum production. Their taper lets Timken bearings take *any* combination of radial and thrust loads. And precision manufacture of Timken bearings assures high precision in the machine.

ENGINEERING SERVICE THAT SAVES YOU TIME AND MONEY. Working with you at the design stage, our sales engineers can often solve your bearing problems on the spot. From the wide range of Timken bearing sizes, types and precisions they can help you select the Timken bearings to give you the maximum in efficient, economical design engineering.

Industry rolls on

TIMKEN®

tapered roller bearings

The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits. Canadian Division: Canadian Timken, St. Thomas, Ontario.

CIRCLE 203 ON READER SERVICE CARD